FIELD CROPS

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Proper soil and climatic conditions, good seed and good culture produce good yields.

FIELD CROPS

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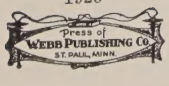

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PREFACE

The extensive use of the previous edition of Field Crops indicates that it fulfilled an acceptable mission when agricultural courses were being formulated and a text of this character was most needed. The study of agriculture has recently received from educators and governmental authority a new impetus on account of the economic importance of crop production. The study of field crops will, therefore, be undertaken more widely than ever before and with a keener appreciation of its value in the national welfare.

In this edition the latest available statistics of acreage and production have been used, including estimates of production in the United States in 1922. World production figures in general are for periods just preceding the World War, as agriculture is still demoralized in some countries and estimates of production are not available. The diagrams of relative production are new. Other changes have been made in numerous places, which, it, is believed, will harmonize with the most recent information.

Field Crops has been prepared for students of high school grade and for those in many other public and private agricultural schools and colleges that desire to teach practical scientific courses in agriculture. Not only as regards subject matter but with special reference also to the language and style of presentation the book has been adapted to the comprehension and interest of the student. It is more personal than bookish.

The work is intended to cover the period of the school year. The time spent upon it, however, may be reduced to a semester by omitting the study of those crops which may

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be less dominant in the interest of a local community and by limiting the number of exercises that are undertaken.

The study of Field Crops does not presuppose a previous course in botany or general science.

Supplementary references have been given at the close of each chapter in the way of Farmers' Bulletins, which may be obtained free from the Department of Agriculture, Washington, D. C., and of standard volumes which should find a place in the school library. The publications of local experiment stations should also be obtained.

The laboratory exercises and field projects which appear at the close of the chapters are merely suggestive, as it is thought that the local conditions and the individual judgment of the teacher will in most instances determine the character of the experiments. In each classroom special emphasis should be given to the particular crops which are of importance in the region where the instruction is given. Frequent visits should be made to farms in the vicinity, and as many of the crops as possible studied at first hand. Small plats of some crops not common in the community may well be grown on the school farm to supply illustrative material.

While the book is designed primarily for text use, the authors trust that it will also be of interest to farmers and to those who desire to become farmers. The results of many experiments have been embodied in the text, as have also the practical experiences of many good farmers. The aim throughout has been to make a simple, practical, readable manual.

Our acknowledgments are due to various officials of the United States Department of Agriculture, and to the Ohio, Kansas, and Minnesota experiment stations for illustrative material.

A. D. WILSON.
C. W. WARBURTON

August 1, 1923.

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FIELD CROPS

PART I—INTRODUCTION

CHAPTER I

CLASSIFICATION OF FIELD CROPS

1. Introduction. The cultivation of crops is one of the first evidences of a permanent civilization. Savages live on the spoils of the hunt and on such fruits, nuts, and other vegetable products as nature supplies. Some of the wandering tribes in the beginnings of civilization domesticated the horse, the ox, and the sheep; but these animals were herded on the natural pasture lands, and the tribes moved from place to place with them as the grasses furnished or failed to furnish pasture for their herds and flocks. The next stage in civilization was the growing of plants for their seeds and fruits to assure the food supply of the tribe and to furnish forage for the domesticated animals. A natural result of this production of crops was the storage of these products for use during winter and against times of famine. Crop production required a more or less fixed habitation for men, as the crop had to be protected from the depredations of animals and of hostile tribes from the time of its planting till harvest, while permanent storehouses for the food supply had to be built and guarded. The building of permanent habitations and the beginnings of home life can thus be traced directly to the cultivation of crops.

2. Agriculture and Horticulture. Agriculture, in the original sense, meant field culture, while horticulture meant the growing of crops within a garden or inclosure. Both words are from the Latin. The difference in terms is due to the fact that the Roman farmers lived within walled inclosures, the better to protect themselves and their stores of food from their enemies. The larger areas in crops, the food grains and the forage for animals, were outside the walls, and the tilling of these crops was agriculture, from *ager*, field, and *cultura*, culture or cultivation. The fruit and vegetable crops, which required only small areas and were given special care, were grown within the walls and their tilling was horticulture, from *hortus*, yard or inclosure, and *cultura*. In modern times, however, agriculture has come to have a broader meaning, including all the operations of the farm, such as stock raising, the production of field crops, horticulture, and the manufacture of dairy and other products. The tilling of the soil and the production of field crops are now usually included under the term "agronomy."

3. Cultivated Plants. The number of cultivated plants other than ornamental, according to De Candolle in his "Origin of Cultivated Plants," is about two hundred and fifty. Of these, four fifths are natives of the Old World. Seventy-seven are cultivated for their fruits, sixty-six for their seeds, and sixty-five for their stems or leaves. Most of the remainder are grown for their underground parts, which may be thickened roots, as the beet, or tubers, as the potato.

4. Field Crops. In this book, only those crops which are ordinarily grown in large areas under field culture (the "agriculture" of the Romans) are included. In general, extensive rather than intensive methods are used in the cultivation of field crops. This rule does not always hold true. The most careful and intensive methods are used in the culture of sugar beets and of some types of tobacco, while fruits and

vegetables that find a wide market are sometimes grown in large areas by extensive, or field, methods.

5. Classification of Field Crops. It is rather difficult to make a definite classification of field crops, for certain uses may be made of a certain crop under one set of conditions and other and very different uses under another. New uses are continually being made of the various crops, so that a classification made now might be materially wrong in a few years. The principal field crops can, however, be included in some one of the following classes: Grain, hay and forage, fiber, tuber, root, sugar plants, and stimulant. This classification is based in part on the portions of the plants which are used, and in part on the uses to which they are put. Medicinal plants and a few others of a miscellaneous nature are not grown to any considerable extent and need not be considered at length.

6. Relative Importance. The 1920[1] census reports show that the total area in field and garden crops in the United States in 1919 was 375,000,000 acres, of which all but about 12,000,000 were in field crops. These 12,000,000 acres were devoted to garden and orchard crops. The total area of improved farm land was more than 503,000,000 acres, leaving something like 128,000,000 acres in pastures and improved woodlands. Of the 363,000,000 acres in field crops, about 219,000,000 acres, or about 60.3 per cent, were in grain crops; 96,000,000 acres, or about 26.4 per cent, in hay and forage crops; about 9.3 per cent in fiber crops; and the remainder in tuber, root, sugar, stimulant, and other crops.

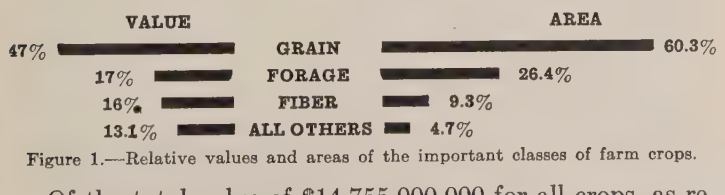

Figure 1.—Relative values and areas of the important classes of farm crops.

Of the total value of $14,755,000,000 for all crops, as re-

ported for the Census of 1920, approximately $6,941,000,000, or 47 per cent, was grain crops; $2,523,000,000, or about 17 per cent, hay and forage crops; and $2,355,000,000, or about 16 per cent, fiber crops. All crops were exceedingly high in price in 1919. The estimated value of all grain crops in 1922, according to the Federal Bureau of Agricultural Economics, was $3,488,000,000. The value of the cotton crop was $1,370,000,000, and of hay and forage crops, $1,332,000,000. Assuming that the grain, cotton, and hay crops in 1922 represented 80 per cent of the value of all crops, as was the case in 1919, the total value of all crops in 1922 was approximately $7,737,000,000, about 48 per cent less than in 1919. Dividing the total value of all crops in 1919 by 6,448,343, the number of farms in the United States that year, gives an average farm value of crops per farm of $2,288, as compared with $863 in 1909. On the basis of the same number of farms in 1922 as in 1919, the average value of crops per farm was $1,192 in 1922.

7. Grain Crops. A grain crop is one which is grown principally for the production of its seeds. The most important grains are the cereals, which are grasses grown for their seeds. The principal cereals in the United States are corn, wheat, oats, barley, grain sorghums, rye, and rice. Millet is also a cereal, although most types of this crop are grown for forage rather than for grain. Buckwheat and flax are the only important grains which are not cereals, unless such crops as peas and beans are included. Field peas, cowpeas and soy beans are usually grown for forage or green manure, but may be harvested for their seeds. The area in corn, wheat, oats, barley, rye, flax, grain sorghums, rice, and buckwheat in 1919, according to the Census figures, was 219,548,000 acres; the total production was 4,671,196,000 bushels; and the total value, $6,950,588,000. In 1922 the figures for the same crops were 226,150,000 acres, 5,403,-

[1]The census is known as the Census of 1920, but the figures of crop yields and values are for the previous year, 1919.

668,000 bushels, and $3,567,216,000, respectively. The acreage, production, and value of each of these crops in 1922 are shown in Table I.

Table I. Acreage, production, and value of each of the important grain crops in the United States in 1922, and the total for all grain crops.

Crop	Acreage	Production	Value
	Acres	*Bushels*	*Dollars*
Corn	102,428,000	2,890,712,000	1,900,287,000
Wheat	61,230,000	856,211,000	864,139,000
Oats	40,693,000	1,215,496,000	478,548,000
Barley	7,390,000	186,118,000	97,751,000
Rye	6,210,000	95,497,000	66,085,000
Grain sorghum	5,051,000	90,381,000	79,389,000
Rice	1,055,000	41,965,000	41,836,000
Flax	1,308,000	12,238,000	25,869,000
Buckwheat	785,000	15,050,000	13,312,000
Totals	226,150,000	5,403,668,000	3,567,216,000

The improved farm land in the United States in 1919 was 503,073,000 acres. Of this total, 46.53 per cent[1] was in grain crops, as follows: Corn, 20.33 per cent; wheat, 14.53 per cent; oats, 7.55 per cent; barley, 1.29 per cent; rye, 1.53 per cent; grain sorghums, 0.72 per cent; flax, 0.25 per cent;

Table II. Relative importance of the grain crops of the United States, as indicated by the percentages of total acreage, production, and value of all grain crops.

Crop	Acreage	Production		Value
		Bushels	Pounds	
	Per cent	*Per cent*	*Per cent*	*Per cent*
Corn	45.29	53.49	58.91	53.27
Wheat	27.07	15.85	18.70	24.23
Oats	17.99	22.49	14.15	13.41
Barley	3.27	3.44	3.25	2.74
Rye	2.75	1.77	1.95	1.85
Grain sorghums	2.23	1.67	1.84	2.23
Flax	.58	.23	.25	.73
Rice	.47	.78	.69	1.17
Buckwheat	.35	.28	.26	.37

[1]This includes 14,500,000 acres of "corn cut for forage" as reported by the Census Bureau under the heading of hay and forage crops.

rice, 0.18 per cent; and buckwheat, 0.15 per cent. The acreage of improved farm land in 1922 is not known, but it probably was not materially different from that in 1919. On the basis of the same acreage, wheat had decreased in 1922 to 12.17 per cent of the total, while oats increased to 8.09 per cent. Changes in the percentages of other crops were slight. The percentage of each of the important grain crops in 1922 as compared with the total of all grains in acreage, yield and value is shown in Table II.

Figure 2.—Abundant farm crops and prosperous, well-tilled farms result when grain and stock farming are wisely combined.

8. Forage Crops. Next to the grains, forage crops are of most importance. A forage plant is one which is fed to stock in the green state or when cured into hay and fodder. The leaves and stems of the whole plant may be used. In addition to the harvested hay and fodder crops, this class includes the pasture plants. The total area in harvested forage crops exclusive of corn in 1919 was 81,618,000 acres, or 16.22 per

cent of the total acreage of improved farm land. The production of hay and forage was 128,549,000 tons, and the value of this forage was $2,316,115,000. No definite value can be placed on the acreage in pasture, which is much greater than the acreage in harvested forage crops.

Nearly all forage crops may be included in one of two general classes, the grasses and the legumes. The first includes timothy, blue grass, redtop, brome grass, Bermuda grass, Johnson grass, and all similar crops; the legumes include such crops as alfalfa, red clover, white clover, cowpeas, soy beans, Japan clover, and field peas. Most of these are grown ordinarily for forage, either as hay or pasture crops, though a few, such as field peas, cowpeas, soy beans, field beans, and peanuts, may be grown for their seeds.

Of the nearly 82,000,000 acres in harvested hay and forage crops other than corn reported by the Census of 1920, 23.7 per cent was in mixed timothy and clover; 21.0 per cent in wild, salt, or prairie grasses, and 13.4 per cent in timothy alone. Alfalfa occupied 10.6 per cent of this area; clover alone, 3.9 per cent; grains cut green for hay, 7.0 per cent; and miscellaneous tame grasses, 7.4 per cent. About 14,500,000 acres of corn are reported as cut for forage.

9. Fibers. The fiber crops grown in the United States are cotton, flax, and hemp. Of these three, cotton is by far the most important. Its cultivation is confined to the southern portion of the country, mostly from Texas and Oklahoma eastward, although there has been some recent development of cotton production in Arizona and California. The cotton crop ranks below corn in value, and is sometimes exceeded by hay, but is usually worth more than the wheat crop. Flax is grown principally for grain, its use for fiber being merely incidental. Hemp is produced in a limited way in a few scattered areas.

10. Tubers. The only important tuber crop is the potato sometimes known as the Irish, or white, potato, to distinguish

it from the sweet potato, which is a root, not a tuber. This is one of our important food crops, the production in 1922 being 451,185,000 bushels, valued at $262,608,000. This is more than the usual production and less than the usual value. Potatoes occupy about three fourths to four fifths of 1 per

Figure 3.—A field of well-cultivated sugar beets, an important root crop.

cent of the area of improved farm land, and rank sixth in value among our field crops.

11. Roots. The principal root crop of the United States is the sweet potato, which was grown on 1,116,000 acres in 1922, with a production of 109,534,000 bushels. Other root crops are grown principally for stock feeding, as the mangel, carrot, and rutabaga. No figures are given for the annual production of these crops by the Bureau of Agricultural Economics, but in 1919 they occupied only 88,333 acres, with a production of 598,945 tons. The sugar beet is a root crop which is of great importance for the production of sugar. It is discussed under the heading of sugar crops in Chapter XXIII.

12. Sugar Crops. Two important sugar crops are grown in the United States, the sugar cane and the sugar beet.

Sugar cane is much the older source of sugar. The development of the sugar beet industry in America is comparatively recent, and it is only in the last few years that the production of beet sugar has surpassed that of cane sugar in the United States. The cultivation of sugar cane is limited practically to Louisiana and Texas, though the crop is grown generally over the South for sirup production. The sugar beet is grown over a wide range of country, from New York to California. The production of cane sugar in the United States in 1922 was 241,400 short tons, while that of beet sugar amounted to 691,000 short tons.

13. Stimulants and Sedatives. The only stimulant or sedative crop which is grown to any extent in the United States is tobacco. This crop was grown on 1,725,000 acres in 1922, or 0.34 per cent of our improved farm lands. The production amounted to 1,324,840,000 pounds, valued at $306,179,000, making it rank sixth in value among our field crops that year. Potatoes usually rank sixth.

14. Miscellaneous and Medicinal Crops. None of the miscellaneous and medicinal crops is grown on a large scale. Among them may be mentioned broomcorn, hops, the castor bean, mustard, and various kinds of mint.

15. The Uses of Crops. The principal uses of field crops are to supply food and clothing for humanity, to feed animals, to maintain or to restore the vegetable matter and the fertility of the soil and to prevent the loss of fertility through erosion or other means. The principal food crops of the United States are wheat, corn, rice, potatoes, and sweet potatoes. Other crops which are used to a greater or less extent for human food are oats, barley, rye, buckwheat, the sugar beet, and sugar cane. The use of barley, rye, and oats as human food in the United States has increased enormously since our entrance into the World War in 1917. The plants which supply material for clothing are cotton and flax. Many plants furnish food for man indirectly by

being fed to animals, to be transformed into meat, butter, and milk. Corn, oats, barley, rye, and the grasses and clovers are the important food crops for the domestic animals which do useful work for man or furnish him with food. Some crops maintain or add to the fertility of the soil by supplying the vegetable matter necessary for the continuance of plant growth. Others, by providing a soil cover which prevents washing, leaching, and other natural losses, help to retain the fertility for the production of useful crops.

Figure 4.—By far the largest part of the corn crop is fed on the farm and marketed in the concentrated form of animal products.

16. The Right Crops to Grow. The choice of field crops for a given farm or locality depends to some extent on the climate and soil conditions, the kind of farming, and the proximity of the market. Climate limits the production of some crops. Cotton, for instance, can be grown profitably only where the summers are long and hot. Winter wheat may thrive where spring wheat is wholly unprofitable. Some crops grow best on a sandy soil; others, on clay. We can materially change the nature of a soil by tillage, drainage, and the application of fertilizers, so as to make it suitable for many crops, but soil types limit to some extent the growth and profitableness of some of our most important crop plants. The quality and value of tobacco are influenced more by

the nature of the soil on which it is grown than by any other factor. It is usually a good plan to follow the general practice of a neighborhood in choosing the crops to grow, though a new crop may sometimes be introduced with profit.

The use which is to be made of a crop is a decided factor in its choice. On a dairy farm, forage crops are of prime importance. The selection of these crops and the relative areas to be devoted to them depend on the special methods which are followed. Some crops are suitable for pasture, others for hay, and still others for cutting for green feed

Figure 5.—On the way to market. Beef represents farm crops converted into a form that is more useful to man.

(soiling). On a farm where beef or pork is produced, the growing of grain is often more important than the production of forage. On a grain or cotton farm, forage production is of little consequence, except to furnish feed for the necessary work animals. Market facilities are often a deciding factor in the selection of crops; for bulky crops like hay might be produced profitably for a near-by market, while the profit would be consumed by the transportation charges if it were necessary to haul the product a considerable dis-

tance. It is usually advantageous to market crops in a condensed form. Feeding forage and grain crops and marketing them in the form of live stock or live-stock products help to keep up the fertility of the soil if the manure is utilized, while the expense of marketing is reduced.

17. Diversification. It is not often safe to depend entirely on a single crop. It is sometimes desirable to make a specialty of a crop, and to become known as a producer of high quality oats or corn or cotton or some other products of unusual excellence. This plan often results in materially increased profits, but only a portion of the farm should be devoted to any particular crop each year. It is often the case that unfavorable conditions which cause a partial or complete failure of one crop may be suitable for another. In diversity of crops there is safety. Some of the reasons for diversification and systematic crop sequence are given in the chapter on Crop Rotation.

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CHAPTER II

THE GROWTH OF PLANTS

18. Introduction. It is neither desirable nor necessary to set down in detail the processes which are involved in the germination of seeds and the growth of plants, the uses of the different elements of plant food, and the effects of tillage, drainage, and other factors on crop production. The study of growth processes is more properly a part of the work in botany, while plant food, cultivation, moisture supply, and other subjects of similar nature may best be discussed along with the study of soils. A brief outline of the way in which plants grow, however, should be of value to the student or the producer of field crops, in affording a better understanding of many of the cultural methods and other matters which will be detailed in the discussion of each crop.

THE SEED AND ITS GERMINATION

19. What the Seed Is. A seed is a reproductive body produced by flowering plants. It contains an embryo plantlet and usually an amount of plant food, all surrounded by one or more seed coats. Nearly all field crops are grown from seed, though a few, such as potatoes, sweet potatoes, and sugar cane, are grown from divisions of the roots or stalks. The seed consists of a minute plant, the embryo, and the store of the plant food which surrounds it. This embryo may be seen very readily in a pea or bean. If the seeds of these plants are soaked in water for a few hours, the skin, or outer protective covering, may be removed easily. If the halves are then separated, a minute plantlet will be found adhering to one of them. This is the live portion of the seed, which, under proper conditions, will start into

growth and produce a mature plant. This plantlet, or embryo, is attached to both halves of the seed in its natural state, and forms a sort of hinge between them. The embryo consists of two parts, the plumule, which grows upward and forms the stem and leaves, and the radicle, which grows down into the soil and forms the roots. The thick, fleshy portions of the seed consist largely of starch, which, as growth begins, is changed to a form which can be used by the embryo, and which supports the plantlet till it can form roots and leaves of its own and obtain its food from the soil and the air.

20. Good Seed. Seed, to be of value, must be viable, or "live." Its viability, or power to germinate and produce strong, healthy plants, depends on the plant which bore it, its maturity, its age, and the conditions under which it has been kept. The plant which bore the seed must have been strong and healthy, or the seed will be weak and lacking in vigor. Live seed must be fully matured. The embryo is not wholly developed in unripe or immature seed, and the supply of plant food is less than in mature seed. Good seed is usually fresh seed. Crop plants differ greatly in the length of time during which they retain their viability, but the vigor and strength of germination usually decrease rapidly after the seed is two years old. The conditions under which the seed has been kept are also of material effect. Ordinarily, seed should be well cured, and kept in a dry place where it will not freeze. Many seeds, however, are not injured by frost if they are fully cured and dry when frozen.

21. Germination. Seeds germinate or start into growth under certain conditions. The essentials for germination are warmth, air, and moisture. There can be no growth below the freezing point, and most seeds germinate very slowly, if at all, below 40 degrees Fahrenheit. The "optimum" temperature, or that at which seeds germinate best, varies with different kinds of seeds, but the range is compar-

atively narrow for any one kind. The optimum temperature for most of the small grains is around 80° Fahrenheit, though germination begins at about 40°. Cotton and corn grow best around 95°, and cotton will not germinate at all much below 55°. Air is necessary for germination; for oxygen, which is an important constituent of air, is needed for certain chemical changes which take place in the plant food stored in the seed. Moisture is also needed, for these changes take place only when water is present; it also furnishes a medium by which the food supply is carried to all parts of the young plant. Plant food from outside sources is not necessary for germination, nor is light. These are required for continued growth, but germination will take place without them. (See laboratory exercises at the end of this chapter.) When planted in the soil, the radicle naturally goes down, while the plumule pushes up to the light, no matter in which position the seed is planted.

22. Planting the Seed. To apply these facts in a practical way, we can readily see that it is useless to plant most seeds till the soil and the air are warm, though such plants as oats and wheat grow best at fairly cool temperatures. For this reason, they can be sown much earlier than cotton or corn can be planted. The soil should be fine and mellow, and the seed should not be covered too deeply, otherwise the necessary supply of air will be shut off and the supply of plant food in the seed will not be sufficient to enable the young plant to reach the surface. A soil that is cloddy or crusted is unfavorable for germination, as it is more difficult for the tender shoots to force their way through it.

The depth of covering and the fineness of the soil desirable for best results depend largely on the size of the seed and the consequent store of plant food it contains. Seed must be planted deep enough so that it does not dry out after germination starts, yet not so deep that the plantlet will have difficulty in reaching the surface. Such coarse seeds as corn

and peas should be planted deeper than clover and grass seed; less care is also required in the preparation of the seed bed. Very fine seeds, like tobacco, may best be sown by sprinkling them on the surface of a very fine seed bed and pressing the seeds into the earth with a board.

Figure 6.—A poorly drained field. Good drainage, permitting the air to penetrate the soil, is an essential condition for the germination of seed and the growth of plants.

Too much water is undesirable, for it not only excludes the air from the soil but causes the seed to rot. On the other hand, a dry soil does not contain moisture enough so that the seed can take up enough to start or develop the necessary growth. The right kind of seed bed is a fine, moist, mellow one —which does not dry out readily and yet allows plenty of air to reach sprouting seeds.

WHAT THE LEAVES DO

23. Assimilation. The leaves are the laboratory, or the workroom, of the plant. Three important processes are carried on in this workroom. These are assimilation, respiration, and transpiration. By assimilation, the tissues of the plant are built up. The carbon dioxide of the air is taken in through the leaf membranes and combined with water to make starch. This process takes place only in the presence of sunlight and only in the green parts of the plant. The green coloring matter (chlorophyll) is of importance to

the growth of the plant, as it absorbs the rays of light. These light rays have the power to split up carbon dioxide into its parts, carbon and oxygen, so that the plant can utilize the carbon and set free the oxygen. This process wholly ceases in darkness, and proceeds much more slowly on dark days or in shady locations than in full sunlight. This explains why most plants grow better in the open than in the shade. The taking up of carbon dioxide and giving off of oxygen also accounts in a measure for the purer air of country districts where trees and growing things abound. The percentage of carbon dioxide in the air in a crowded city is often double that in the country.

24. Translocation. If the leaves made starch continually during the daylight hours and it remained where it was manufactured, they would soon become thick and bulky and their stems would be unable to support them. As in most good factories, however, a means is provided of taking the manufactured product and carrying it to other parts of the plant. This is a part of the process of assimilation, and is called translocation. It takes place during the hours of darkness. Starch itself is not directly soluble in water, but the leaf cells contain substances called enzymes, which change the starch to sugar, and, as every one knows, sugar is readily soluble. The sugar is then taken up in the sap and carried to the stem or seeds or roots, where it is stored.

Many plants which live from year to year store large quantities of food in their roots over winter and are thus able to start into growth very early in the following spring. If no leaves are produced, no starch can be made and hence none can be stored in the roots. This fact supplies us with an excellent method of fighting weeds like quack grass and Canada thistle, which are serious weed pests largely on account of the food they store and the resulting vigor of their growth. If these plants are prevented from reaching the light by continuous cultivation, they will be unable

to store additional food, while each attempt at growth reduces the supply in the roots. Eventually this will become exhausted and the plant will die. We can readily see that a plant must be well supplied with leaves in order to produce a good crop of seed or fruit, for the leaves furnish the starch from which a large part of the matter in these seeds and fruits is made. If the leaves are destroyed by insects or disease or in any other manner, the production of seed is naturally lessened.

25. Respiration. The process of respiration is in large measure exactly the opposite of assimilation. It is constantly taking place in all parts of the plant, just as animals must breathe continually to live. By this process a portion of the carbon of the plant is oxidized, or changed back to carbon dioxide; but this change is much less rapid than the formation of starch during the day by the leaves, else there could be no growth or increase in weight by the plant. Plants are giving off carbon dioxide constantly, but the volume given off during the day is much less than that taken up, so that the air is purified. At night, no carbon dioxide is taken up, while the process of respiration continues to give it off. For this reason, the air is purer at the close of a sunshiny summer day than it is the following morning. For this reason, also, growing plants are not desirable in a sleeping room at night, though they help to purify the air in the house during the day.

26. Transpiration. The third important work of the leaves is the giving off of water, or transpiration. On the green, growing portions of the plant, but more particularly on the under side of the leaves, are minute pores, or stomata. It is through these pores that the plant takes in carbon dioxide and gives off oxygen in the assimilation process and also gives off carbon dioxide in the respiration process. These pores are ordinarily open so that water passes from them freely in the form of vapor. When the supply of moisture

which can be obtained from the roots decreases, or the air conditions are such that water is drawn from the plant more rapidly than it can be supplied by the roots, these stomata gradually close, thus checking transpiration and tending to maintain the proper quantity of water in the leaves and tissues of the plant. Some plants possess the power of retaining their water content to a marked degree and are able to live with a very small water supply. Cacti and other desert plants have this characteristic, and the sorghums are among the most drought-resistant of cultivated crops.

The quantity of water transpired by plants during their period of growth is enormous. It is estimated that corn gives off 270 pounds of water for every pound of dry matter which is produced, while nearly twice this quantity is transpired by oats in the making of a pound of dry matter. The quantity transpired varies with the kind of plant and the climatic conditions. Where evaporation is very rapid, the quantity of water required by plants is greatly increased.

THE ROOTS AND THEIR USES

27. What the Root Is. The root is the portion of the plant below the surface of the ground, by which the plant maintains its position. The roots hold firmly to the soil and prevent the plant from being blown from place to place. Some plants, like clover and alfalfa, have taproots which extend straight down into the soil, though they may be changed somewhat in direction by obstacles or by supplies of air, water, or plant food. From these taproots, branches are sent out which spread through the upper portions of the soil. Other plants, like wheat and corn, send out several fibrous roots with many branches which extend into the soil in all directions. Roots are of many kinds and shapes, from the fibrous ones of the grasses to the long, slender taproot of alfalfa and the heavy, thickened root of the mangel and sugar beet.

28. How the Root Grows. All roots are alike in that they end in a rather hard, pointed portion about a quarter of an inch long called the root cap. It is by means of this root cap that the young, tender root forces its way between the

Figure 7.—Roots of young oat plants. Notice the abundance of root hairs; also the growing tips, which push through the soil.

soil particles. The lengthening of the root takes place just back of the root cap rather than along the entire length, so that the root is enabled to find its way around obstacles, such as pebbles and other impervious objects in the soil. It is evident that a fine, mellow soil is important for the free growth of roots, as it is more easily penetrated by them. Just back of the root cap are small rootlets, or root hairs, which are the feeding roots of the plant. These root hairs come into very close contact with the soil particles, as will be found when a plant is dug up and the earth is washed from

the roots carefully. It will be very hard to remove all the fine particles of soil from these root hairs, so closely do they cling. These root hairs will be found along only a few inches of the growing portion of the root just behind the root cap.

29. Roots Take in Water. It has already been stated that the leaves of plants give off water by transpiration. Naturally, there must be some source of supply from which this water is drawn and some means of conveying it to the leaves. The source of supply is the moisture in the soil; it is taken in through the roots, whence it passes through the stem to the leaves. The inner bark of the root and the stem is made up largely of hollow cells placed end to end, which make a ready means of passage for this water, or sap, as it is ordinarily called after it is taken in by the plant. A shortage in the supply of soil moisture is soon evident from the wilting which takes place when water is given off more rapidly than it can be taken in by the roots. Plants cannot draw all the water from the soil. Clay soils will retain more than sandy soils. It is easy to see that a reduction of the root surface lessens the supply of water which the plant can obtain, hence cultivating corn so deep that some of the roots are cut causes the plants to wilt and checks their growth. The gardener removes part of the leaves from his plants and prunes his trees in transplanting them so as to reduce transpiration and lessen the danger from wilting, for he knows that part of the roots have been broken off and those that remain cannot supply enough water for the full leaf surface.

30. Roots Require Air. As with all other living parts of the plant, the roots are constantly taking in oxygen and giving off carbon dioxide; that is, the process of respiration is in progress. Consequently, roots require air. Most plants cannot grow in a soil that is so filled with moisture that air is largely excluded, though a few plants have become adapted to this condition. Plants do not root deeply when there is an oversupply of moisture, for it is not necessary for them to

extend their roots to obtain water, nor is there sufficient air in the soil for the healthy growth of roots. Consequently, plants in wet locations often suffer first when dry weather comes, for their root systems are so small and so shallow that they are unable to obtain enough water. For the same reason, plants are more likely to be damaged by a drought which follows a wet spring than by one succeeding a moderately dry one. Enough water, but not too much, is essential for the best growth of plants. Good drainage helps by taking off the surplus water and allowing air to penetrate the soil, thus inducing deeper rooting.

31. Roots Take in Plant Food. When the chemist analyzes a plant, he finds many things besides the carbon which is taken from the air and the water with which it is combined to make starch. He finds compounds of nitrogen, phosphorus, potassium, calcium, and other substances. Now these elements, with the exception of nitrogen, are not to be found in the air in appreciable quantities, and the nitrogen of the air is not in a form in which most plants can use it. Phosphorus and potassium and the other things are to be found in the soil, for soil is simply decayed or disintegrated rock, and these elements are a part of all rocks. The surface soil which is penetrated by the roots also contains decaying organic matter, and it is from this that plants obtain their supply of nitrogen. Nitrogen, phosphorus, potassium, and the other elements can not be taken in by the roots of plants and pass through their tissues in a solid state, hence they must be in a soluble form so that they can be carried by the water which is drawn in by the roots. Most of the compounds of these elements are not soluble in pure water, but the water in the soil contains some carbon dioxide given off by the roots, and this carbon dioxide is an efficient aid in dissolving the material in the soil particles. These compounds of potassium, nitrogen, phosphorus, etc., are known as plant food.

No treatment	640 lbs. nitrate soda	320 lbs. nitrate soda
2,590 lbs. hay per acre	320 lbs. acid phosphate	320 lbs. acid phosphate
	80 lbs. muriate potash	80 lbs. muriate potash
	7,590 lbs. hay per acre	7,110 lbs. hay per acre

Figure 8.—Relative quantities of hay produced from plats variously fertilized. Plenty of nitrogen is essential to good hay crops. Nitrogen constitutes a basic element of protein, which is an important element in foods and feeds. Those crops, therefore, that have high protein values require an adequate supply of nitrogen for the construction of leaves, stems, and grain. Nitrogen is particularly beneficial to grasses, which suffer less from its excess than cereals.

20 tons manure	10 tons manure	No treatment
7,420 lbs. hay per acre	4,350 lbs. hay per acre	2,230 lbs. hay per acre

Figure 9.—Grass makes better use of barnyard manure than any other crop.

ELEMENTS OF PLANT FOOD AND THEIR USES

32. Nitrogen. In order to understand the nature and uses of the different elements of plant food, we must know something of chemistry and of soils. Only the most elementary statements regarding them will be made here, however, and no attempt will be made to explain the functions or forms of these elements. Nitrogen, though present in the air, cannot be used by plants in the form in which it occurs there. Plants can utilize "combined" nitrogen only; that is, nitrogen combined with some other element or elements. The bacteria which live on the roots of certain plants have the power of taking nitrogen from the air and changing it into a form in which it is available for the use of the plants on which these bacteria live. When the roots or any portion of such plants decay in the soil, the nitrogen in them is made soluble, and a portion of it becomes available for any plants that may subsequently grow in the soil. The air is, therefore, one great source of nitrogen. Another is decaying vegetable matter in the soil, which is acted upon by other bacteria and changed to the nitrate form, in which plants can use it. These bacteria are able to work only in warm, moist soil which contains plenty of air. They thus supply another argument for good tillage and drainage.

33. Phosphorus. Phosphorus is a part of nearly all rocks from which soil is formed, though in many soils the quantity is so small that it is soon reduced below the needs of crops. In sour, or acid, soils the supply of phosphorus is largely in an insoluble form that cannot be used by plants. Ordinarily this condition can be corrected by applying lime, but on soils which are very acid, as marshes and other low, wet lands are likely to be, the application of lime is not practical and it is necessary to supply phosphorus in an available form in order to grow crops. It is obtained from deposits in the soil in certain sections and from stockyards where large numbers of animals are slaughtered, as

bones are very rich in this element. The ordinary forms of phosphate fertilizers are raw bone meal, raw rock phosphate, and acid phosphate.

34. Potassium. Potassium, or potash, the latter the form of potassium to which reference is usually made, is the third great element of plant food. Like phosphorus, it is present to a greater or less extent in all soils, but sandy soils contain less of it than clay and loam soils, while the supply in peat and muck is comparatively small. A very large part of the potassium in the soil is in a form which is not available for the use of plants and, as it becomes available very slowly, it occasionally is not present in sufficient quantity for plant growth. It is much less likely to be lacking than phosphorus or nitrogen, however. The supply of potassium in commercial fertilizers is obtained from mines, the most important of which are in Germany. Sea weed now promises to be a source of this element. Wood ashes are also used to supply potassium to the soil.

35. Other Elements. Other elements which are necessary to plant growth, but which are usually present in all soils in sufficient quantity so that no attention need be paid to them, are calcium, iron, magnesium, and sulphur. Silicon, chlorine, and sodium are also usually present in plants, but they do not appear to be necessary for growth. Calcium contained in lime corrects the soil acidity, which is harmful to most plants; it is also essential to leaf growth. Lime is also necessary for the development of the bacteria which change the nitrogen of the air and that in decaying vegetable matter into forms which can be used by plants. Iron is an essential part of the green coloring matter of plants (chlorophyll), without which carbon dioxide cannot be broken up and starch manufactured. Lime is the only one of these elements which is at all likely to become depleted. Liming to correct soil acidity is very commonly practiced in the eastern and southern United States.

36. Sources of Plant Food. The rocks from which the soil is made are the principal source of all the mineral elements of plant food. Decaying vegetable matter is also an important source, for all the elements of plant food are taken up by plants and naturally they are returned to the soil when these plants decay. The two most important sources of decaying vegetable matter are the plants themselves, either the roots and stubble which are left when the crop is harvested or the entire plant which is turned under as green manure, and barnyard manure. Barnyard, or stable, manure is made up of bedding and parts of plants which are not eaten by animals and also of the material in the feed they consume which they are unable to digest and assimilate, so that it is all vegetable matter. When this matter is incorporated in the soil, it is acted upon by bacteria and molds and reduced to forms in which it can again be used by plants. Another important source of plant food and one which is largely used in the eastern and southern states is commercial fertilizers. These are composed mostly of refuse animal matter from stockyards and of mineral matter which is taken from certain soil deposits containing the desired elements.

37. Humus. The partially decayed vegetable matter in the soil is usually called humus. The term humus, however, as commonly used, has so many different meanings that it is confusing. On this account the term vegetable matter is used here, because it includes the fresh supplies of vegetable matter, such as roots, stems, and manure, as well as that which is partially decayed. The properties usually credited to humus are found also in the fresher forms of vegetable matter. In addition to supplying a source of plant food, it has considerable effect on crop growth in other ways. Soils which contain plenty of vegetable matter are easier to work than those which are lacking in it, for they hold moisture better and are less likely to bake and become cloddy. The acid developed by the decomposition of vegetable matter

helps to dissolve some of the mineral matter in the soil and make it available for plants. The dark color of soils is due largely to the presence of an abundance of humus. As dark colors absorb the sun's rays more completely than light ones, dark soils, or those rich in humus, are warmer than those which are lacking in it. It is evident that it is important to maintain a plentiful supply of humus in the soil.

38. Content of the Various Elements at Different Stages. Different plants draw on the supply of the various elements of plant food in different proportions. They also vary in their composition and in their draft on the soil at different stages of growth. The quantity of potash, for instance, in a crop of wheat increases up to the time when the crop is fully headed, after which it decreases till at harvest nearly half the potash the plant contained has been lost. This potash is washed out by rains and dews or it is returned to the soil by way of the roots. The greatest quantity of nitrogen is also to be found in the cereals and grasses at about the time when the plants are in blossom; later the nitrogen content decreases. The quantity of phosphorus increases as long as growth continues and does not noticeably decrease at maturity. With other crops which do not dry out when ripe, as the potato, there is no loss of any of the elements when the plant is mature. The composition of the mature plant, however, does not necessarily show the quantity of food material which has been used during growth.

39. When the Different Elements Are Needed. Plants differ in the time at which they need the various elements of plant food just as they differ in the proportion of these elements which they utilize. In general, nitrogen is most largely used in vegetative growth (the production of leaves and stems) and is drawn on more heavily in the earlier stages of growth than toward maturity. Forage crops require a specially liberal supply of nitrogen. Phosphorus, on the other hand, is an important constituent of seeds and

fruits, and is used more largely as the plant matures. All the elements, however, are used more or less during the entire growth of the plant.

40. Result if an Element Is Lacking. If any one of the important elements is lacking, continued healthy growth is not possible. If nitrogen is wanting, the growth will be slow and stunted and the plants will be yellow and sickly in appearance. A shortage in the supply of potash often produces weak, flabby plants which are likely to lodge. Calcium seems to be necessary for the growth of leaves, and iron for the development of the green coloring matter. Phosphorus is more necessary for the production of seed than for the growth of the stems and leaves, and plants will make a larger growth if this element is lacking than if any other of the important ones is not supplied. Potash apparently has more or less influence on the formation of starch. Potash is found most largely in the stems and leaves, and nitrogen and phosphorus in the seeds of most plants.

41. Necessities for the Growth of Plants. To summarize the preceding paragraphs, plants require air, sunlight, water, heat and plant food in order to grow. Air is necessary to supply carbon for the making of starch and for the respiration of plants. Sunlight is required in the manufacture of starch and other compounds, for plants can break carbon dioxide into its parts only in the presence of sunlight. Water is needed to combine with the carbon to make starch, to act as a carrier of plant food, to evaporate from the leaf surfaces and keep the plant from getting too warm, and to give rigidity to the cells of the plants. Heat must be present in the optimum degree for the best germination. Plant food is required to make the different compounds which compose the plant. Soil is not necessary for the growth of a plant, for many plants will mature in water if their positions are constant and the necessary plant food is supplied. Practically, however, soil is a necessity.

Figure 10.—Experimental plats at the Minnesota College of Agriculture. Varieties of plants are tested and the best ones singled out and developed.

THE PRODUCTION OF SEED

42. Reason for Seed Production. It is the function of nearly all plants to produce seed so as to perpetuate their kind. Very frequently man has taken advantage of this circumstance and has used the seed for his own purposes. It is the seed of corn, wheat, oats, rye, and other grains which is used as food by man; he also uses the seeds, stalks, leaves, and roots of many plants to feed domestic animals. He uses the lint, or fiber, which is attached to the seed of cotton, and a large variety of products are made from the seed itself. Nearly all our cultivated crops must be grown from the seed every year. Hence the subject of seed production is important to the farmer and the student of field crops.

Figure 11.—Flowers of flax.

43. Reproductive Organs. The flowers are the reproductive organs of the plant. They consist usually of a protective green covering, the calyx; the corolla, a colored portion, the main function of which is to attract insects that are of assistance in pollination; a number of stamens; and one or more pistils. The stamens and pistils are the essential parts for the production of seed. The stamen consists of a slender stem, the filament, and an enlarged upper portion, the anther; the anther contains a fine dust, usually yellow in color, the pollen. The lower portion of the pistil is the ovary, which later develops into the fruit or seeds; the upper portion, usually somewhat enlarged, is the stigma; connecting these two is the more or less elongated central portion, the style. The style contains a slender tube through which the pollen grain grows down

from the stigma to the ovary to fertilize the ovule, or young seed. On most plants, both stamens and pistils are on the same plant and are parts of the same flower. In corn, the stamens are borne in the tassel, while the pistillate flowers are in the ear, the silks being the styles and stigmas of the pistils and the young kernels the ovaries. In some flowers, as in the grasses, the calyx and corolla are replaced by scales or are wanting. A typical flower in which all the parts are readily seen is that of flax.

44. Fertilization. When the ovules are ready for fertilization, the stigma becomes moist and sticky so that it catches and holds the pollen grains that come in contact with it. The anthers open and shed their pollen. It may fall directly upon the moist stigmas, or be carried there by the wind, by insects, or by other agencies. In any case, a pollen grain germinates and grows down the slender tube of the pistil from the stigma to the ovary, where it fertilizes the ovule. The ovule then develops and eventually matures into a seed; if it is not fertilized, it withers away. The characters of the male and female plants are thus united in the embryo of the seed. The ovary may contain one, several, or many seeds. In the grains and grasses, it contains one; in flax, several, usually five, seeds are produced; in some weeds, notably purslane, or "pussly," the number of seeds produced by one flower runs into the hundreds. The grains of corn each represent a flower, of which the silk is the pistil. The flowers form a compact spike on the cob, or rachis.

45. Close and Open Fertilization. When a flower is so constructed that it is normally fertilized by its own pollen, it is said to be close-fertilized. Such are the flowers of oats, wheat, barley, and many of the grasses, many of which are fertilized before the flowers open. Different varieties of these plants may be grown side by side without danger of mixing. An open-fertilized flower is one that may be fertilized by pollen from another flower either on the same plant

or on a different one. In many plants, it may be fertilized either by its own pollen or by that from some other flower; in some, it must be fertilized by pollen from another flower, and the results are better if this flower is on another plant. In corn, open pollination is assured, because the pistillate and staminate flowers are on different parts of the plant, and the pollen is not shed till several days after the ovules on that stalk are ready for fertilization, so that corn growing in a field is almost certain to be cross-fertilized. As pollen is carried some distance by wind, varieties planted near together are almost certain to mix if they "silk" about the same time.

46. Crosses and Hybrids. A cross is produced by the union of two varieties. If Reid's Yellow Dent corn is fertilized with pollen of Leaming or Boone County White or any other variety, the result is a cross. In the original meaning of the word, a hybrid was the product of the union of two species, as wheat and rye, but the term is now commonly used in the sense of a cross between varieties of the same species. True hybrids are seldom fertile; that is, they will not produce seed. Thus in the case just mentioned, numerous hybrids of wheat and rye have been produced, but in very few cases have these hybrids produced seed which would germinate. The process of cross-fertilization by artificial means is frequently used for the production of new varieties. Considerable care, time, and selection must be devoted to crosses in order to get them to "come true," that is, to produce uniformly the type of plant which is desired.

47. Improvement by Selection. The principle that like produces like is used by plant breeders in the improvement of varieties. If seed is continually saved from the best individuals in a field of wheat or other close-fertilized plant, a very noticeable improvement can be effected in a few years. In the same way, if the best individuals of open-fertilized plants are saved for seed, improvement will result, but care

must be taken to prevent the introduction of pollen from inferior plants. Thus an ear of corn may appear to be excellent, but some of the kernels may have been fertilized by pollen from inferior stalks and the plants they produce will be inferior. A large part of this "bad blood" may be eliminated by going through the field when the plants are in tassel but before the pollen is shed and pulling out the tassels of the weak stalks and others that do not show promise of producing good ears. The improvement of plants is very interesting and should receive the attention of many more persons than now devote their energies to it.

LABORATORY AND FIELD EXERCISES

1. Soak several beans or peas in tepid water for 24 hours. Then examine them, noting how they have swelled and how easily the outer skin may be removed. Separate the halves and examine the embryo which remains attached to one of them. At the same time put a few beans in ice water and keep the water below 40 degrees, if possible, but avoid actual freezing. Note how little the seeds have swelled in comparison with the others. Also soak a few beans for the same length of time in tepid water containing a spoonful of common salt. Note that they have not swelled as have those in warm water. Seeds have the power of keeping out undesirable solutions and will not germinate in soils containing any considerable quantity of salts.

2. Plant several beans in a small box of good soil; plant kernels of corn in a similar box. Keep the soil moist, but not wet. In a few days the plants will appear. Note how the young shoot of the bean has pushed the halves of the seed apart and forced them to the surface, while the kernel of corn remained below. Dig up one plant of each carefully and note the difference in the root system; also how the young corn plant is still attached to the kernel. A few days later note that the thick halves of the bean have gradually disappeared; also that the corn kernel has decreased till little more than a shell is left. The plant is drawing on its supply of food stored in the seed. Soon the green leaves will begin to manufacture food from the air, while the roots will draw on the supply in the soil.

3. Plant beans in another box or pot. As soon as they appear above ground, cut off parts of the thick "seed leaves" with a knife, being careful not to injure the young plant. Leave one or two plants

undisturbed. Note that the vigor of growth depends on the quantity of plant food available, as indicated by the size of the portions which were allowed to remain. Portions of the starchy upper part of the corn kernel may be cut away before planting without injuring the germ. Cut several kernels in this way. Note effect on germination and growth.

4. Cut five or six thicknesses of blotting paper the size of a large plate, place in the plate and have another plate of the same size to turn down over it. Make several of these small germinators and place fifty grains of wheat, oats, or barley between the blotting paper in each; moisten and keep moist the blotting paper in all but one. (Several thicknesses of cloth may be used instead of the blotting paper if desired.) Set one of the germinators in a cool place and another where it remains at about the ordinary temperature of the room, 70 degrees. Place the dry germinator alongside the moist one in the warm room. Set one germinator in a warm, light place and another in a warm, dark one. Let no germinators become dry except the one which was started that way. In five or six days examine all of them and see what has happened. Is moisture necessary for germination? Is light? Is heat?

5. Plant several beans in pots or small boxes of good soil; after the plants appear set one box in a cool place, but where it will not freeze; put another in a dark room or closet; place the remainder in a warm, sunny window. Set one of the pots in the window and let it dry out; plunge another in a pan of water to the top. Keep the others moist but not wet. In a few days compare the growth which has been made. Is light necessary? Is heat? Moisture? Do the roots need air?

6. If there is sufficient time, a large number of other exercises may be worked out, showing that plants need air, light, moisture, plant food, and heat; how they utilize these different factors, and the results, if any are lacking. Farmers' Bulletin 408, School Lessons in Plant Production, may be obtained free by any teacher and will be very helpful in suggesting useful exercises for the laboratory. The first four chapters of A. D. Hall's "The Feeding of Crops and Stock" will be found very readable and instructive, as well as suggestive of numerous methods of illustrating the germination of seeds and the growth of plants.

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PART II—GRAIN CROPS

CHAPTER III

CORN

ORIGIN AND DESCRIPTION

48. Nativity. Corn, *Zea mays*, is a native of America. Though it is a true grass, none of the known native or wild grasses resemble it very closely, and the species from which it was developed has never been determined. All that is known is that it was cultivated by the Indians when America was discovered by Columbus. It is generally agreed that corn was first introduced into Europe by Columbus on his return from his voyage of discovery, and that its growth in Europe and Asia has spread from that original importation and from later ones from this continent. Corn is reported to have been first grown by white people within the present limits of the United States in the colony of Virginia in 1608.

The term "corn" is used in Europe to designate any kind of grain, as wheat, oats, or barley, and it was so used before the discovery of America. When the cultivation of Indian corn, or maize, was introduced, the same term was applied to it. The confusion in the meaning of the word and the consequent belief that corn was grown in Europe before the journeys of Columbus to the New World are doubtless due to this use of the word, which is now legally accepted as meaning maize, or Indian corn. It is unanimously conceded that corn is a native American plant, first grown and used by the Indians of this hemisphere. Conclusive evidence of its nativity is indicated by its connection with mythological and religious ceremonies of the Indians and the discovery of ears of corn buried with mummies in Peru and Mexico.

49. Botanical Characters. Botanically, corn is a grass; that is, it belongs to the same family of plants as timothy, wheat, and blue grass. The roots are fibrous and spread several feet in the ground in all directions, the extent varying with the type of soil and the weather conditions. After the plant is partly grown, brace roots grow out from one or two, and in some cases several of the lower joints. Their function is simply to brace the plant, to aid it in withstanding the strain caused by the wind.

The stem, like that of all the common grasses, is made up of nodes and internodes, varying greatly in length in different varieties and different seasons. The internodes are much longer near the top than near the bottom of the stalk. The stem, which is flattened or grooved on one side, has a hard fibrous coat or outer wall and a soft, spongy pith, differing in this respect from the hollow stems of most grasses. The height of the plant varies from 2 to 20 or more feet; the usual height is from 5 to 10 feet.

The leaves grow out from the nodes. As in other grasses, they clasp the stem in the form of a sheath which fits very closely. Where the leaf spreads out from the stalk, the sheath clasps about it so tightly that under ordinary circumstances water is prevented from getting in between the sheath and stem. The blades of the leaves vary in breadth from 2 to 4 inches and in length from 2 to 4 feet. The leaves have the useful habit of rolling up from the edges when there is a shortage of moisture, thus greatly reducing the transpiration from them.

The male and female flowers of corn are borne on different parts of the plant. The tassel bears the male flowers and the silks are the visible parts of the female flowers. The male flower produces the pollen which is to pollinate the female flower. As it is produced at the top of the stalk, the pollen easily falls by gravity or more commonly it is blown from the tassel to the stigma of the female flower. On

account of the manner of pollination and because many corn plants are usually grown together, crossing very generally results; that is, pollen from one plant fertilizes the ovaries of other plants, so that corn is usually cross-pollinated. In fact, this habit is so general that a stalk growing by itself seldom, if ever, produces a good ear, because of imperfect fertilization of the flowers.

50. Mixing of Varieties. The flowering habits of corn make it extremely difficult to maintain pure varieties, as they will mix at considerable distances. For this reason it is highly desirable for a community to grow but one variety. If adjoining farms produce different varieties, each is very likely to be mixed with the other. In favorable weather, the pollen grains may be carried by the wind at least 200 rods, if there is no obstruction in the way. The fact that the prevailing winds in the corn belt are from the southwest during the season of the year when corn is blossoming is made use of to some extent by locating the seed plat from which seed for the next year's crop is to be selected, where the wind blows from it to the other corn fields, rather than from the other corn fields to it.

CLASSIFICATION

51. Variation. All the varieties now so common in every section of the country are the result of selection and breeding from the original Indian types, which were very inferior to those grown at the present time. Very little was done to improve corn until the middle of the nineteenth century, but during the past seventy years improvement has been very rapid till at present there are hundreds of named varieties. Some of these varieties mature in 90 to 100 days and produce small ears with shallow kernels, while others require 140 or more days to mature and produce large, deep-kerneled ears. In color, corn kernels may be yellow, white, red, black, blue, or a mixture of some of these colors and shades. The cobs

are either white or red. Most of these colors of kernels with the variation of color in the cobs may be found occasionally in any of the important classes of corn.

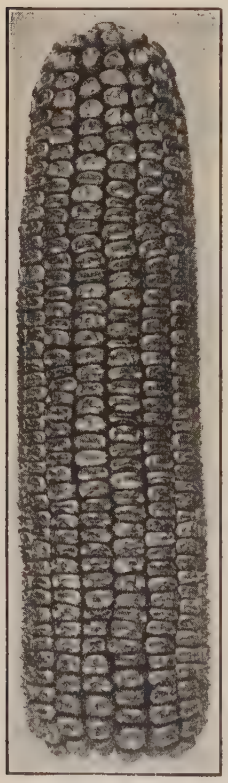

Figure 12.—A good ear of a small, early variety of dent corn adapted to the North.

52. Classes or Types. All the more important varieties and types of corn may be grouped into one of the four following classes, viz.: dent, flint, sweet, and pop. Two other classes, soft, or flour, and pod, are of little practical value in North America, but the others have a very important relation to the agriculture and commerce of the world.

53. Dent Corn. Dent corn is a type in which the hard, or horny, part of the kernel is at the sides and does not extend over the crown as it does in flint and pop corn. This arrangement causes the crown of the kernel to shrink at maturity, making an indentation which distinguishes dent corn from other types. This is the most important type of corn; probably 90 per cent of the total corn crop of the world is in this class. The characters which make it more valuable than other types are that (1) it yields more; (2) it does not produce many suckers or tillers; (3) it is easily husked; and (4) it is comparatively soft and easy for animals to masticate. Generally speaking, it is larger and later than flint corn, though there are small, early maturing varieties of the dent type. Ears of dent corn may vary in size from 4½ to 10 inches in circumference and from 6 to 12 inches in length.

54. Flint Corn. Flint corn ranks next in importance to the dent type. The crown of the kernel as well as the sides is covered with a hard, horny part which does not shrink, or at least shrinks evenly, at maturity. This gives each kernel a hard, smooth, flinty appearance, to which the name of the type is due. Ears of flint corn are usually longer in proportion to their circumference than ears of dent corn. There are fewer rows of kernels on the ears, the furrows between the rows are usually wider, and the kernels are comparatively shallow. It is very prolific in the production of suckers or stools, making it quite valuable as a fodder crop, but it does not yield as much grain as most of the varieties of the dent type. The ears have a larger proportion of cob to corn than is found in the dent varieties; the shank of the ears is usually large, making flint corn much harder to husk than dent corn. Flint corn is usually earlier in maturing than most dent varieties, hence it is specially adapted to northern latitudes, but it has little agricultural value where the more desirable dent varieties thrive. It is used to some extent as human food in the form of hominy, and is regarded as preferable for cornmeal.

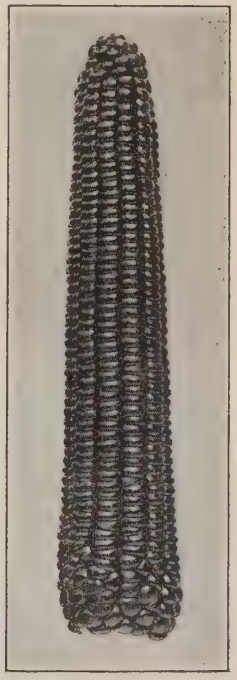

Figure 13.—Ear of flint corn.

55. Sweet Corn. Sweet corn has practically no hard, or horny, endosperm. Consequently, the whole kernel usually shrinks at maturity, presenting a shriveled appearance. As indicated by its name, its chief characteristic is that it contains a higher percentage of sugar than the other types.

It is grown chiefly for human food and is highly prized as a table vegetable both when green and fresh in the summer and when canned or dried for winter use. There are many varieties of sweet corn, differing in size and in length of time they require to mature. The stalks are smaller and finer than the stalks of most varieties of dent corn. Sweet corn is grown very little for feed for animals, except that it is sometimes used for fodder or for early fall feed for live stock.

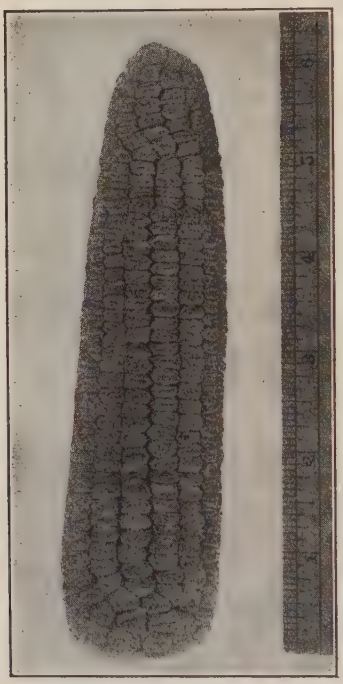

Figure 14.—An ear of sweet corn of the Stowell's Evergreen type. A large, late variety.

56. Pop Corn. Pop corn is grown only as human food to be eaten when popped; that is, when the kernels have been puffed by heating. It is this peculiar character from which it gets its name. The kernels are covered with a hard, flinty covering as are the kernels of flint corn; in fact, a large proportion of the kernel is hard and flinty. Some kernels are sharp-pointed at the crown, while others are rounded and smooth like flint kernels. The kernels, ears and plants are very much smaller than the other kinds of corn mentioned. On this account it is of little value for the production of feed for live stock.

57. Varieties. A study of local varieties is necessary and advisable, but there are far too many named varieties in the

United States to make it worth while to attempt an enumeration of them. Corn is so easily changed by selection that one may not be able to recognize a well-known variety after some one else has been growing and selecting it for some time. This is especially true if it has been grown under different soil and climatic conditions from those in which he has seen it grow before. On this account, varietal names are not important, but types of corn and their adaptability to various conditions must be thoroughly understood by practical corn growers. (See Selection of Corn, Sections 121-132.) A few of the important and widely distributed varieties of corn are Reid Yellow Dent, Boone County White, Silvermine, Goldmine, Legal Tender, Silver King, Minnesota No. 13, and Wisconsin No. 7. These are northern or "single-ear" varieties.

IMPORTANCE OF THE CROP

58. World Production. Corn is a tropical plant that can withstand very little frost. It seems best adapted, however, to the temperate zone and it is here that it reaches its most perfect development. The leading countries in the production of this crop normally are the United States, and Argentina. Hungary, Rumania, Egypt, Australia, and South Africa also produce some corn. According to the Bureau of Agricultural Economics of the United States Department of Agriculture, the average annual world production for the five years from 1909 to 1913 was 3,800,000,000 bushels, of which 71 per cent was produced in the United States. These figures are given preference, because the World War disturbed subsequent conditions.

59. Production in the United States. The average acreage, production, yield, and value of corn in the different states for the years from 1918 to 1922 are shown in Table III. The relative production is shown in Figure 15.

60. Relative Importance. Corn is grown on a larger acreage and produces a larger total yield than any of the other

Table III. Average acreage, acre yield, production, and farm value of the corn crop in each of the leading states during the 5-year period from 1918 to 1922, inclusive, with the percentage of the total production in each state.

State	Area, acres	Acre yield, bu.	Production, bushels	Farm value, dollars	Percentage of total production
Iowa	10,086,000	42.1	438,026,000	320,658,000	15.12
Ill.	9,035,000	35.1	317,279,000	260,833,000	10.95
Nebr.	7,252,000	26.1	190,586,000	129,781,000	6.58
Ind.	4,840,000	36.7	177,513,000	139,845,000	6.13
Mo.	6,309,000	27.5	173,132,000	148,403,000	5.98
Ohio	3,823,000	40.5	155,302,000	130,536,000	5.36
Minn.	3,373,000	38.3	128,469,000	90,461,000	4.43
Texas	5,792,000	22.2	125,928,000	118,328,000	4.35
S. Dak.	3,565,000	30.6	108,856,000	72,225,000	3.76
Ky.	3,328,000	26.8	89,159,000	90,135,000	3.08
Wis.	1,996,000	43.8	87,774,000	74,151,000	3.03
Kans.	4,956,000	18.1	87,001,000	60,473,000	3.00
Tenn.	3,401,000	24.4	83,241,000	84,295,000	2.87
Penn.	1,556,000	44.8	69,794,000	72,546,000	2.41
Ga.	4,482,000	14.3	64,158,000	73,325,000	2.21
Mich.	1,676,000	36.1	60,537,000	54,739,000	2.09
Okla.	2,962,000	20.5	59,880,000	45,057,000	2.07
Ala.	3,861,000	14.7	56,574,000	63,265,000	1.95
N. C.	2,613,000	20.4	53,225,000	69,341,000	1.84
Miss.	3,121,000	16.7	52,291,000	57,796,000	1.80
All others	13,874,000	22.9	317,641,000	352,741,000	10.99
U. S.	101,901,000	28.4	2,896,366,000	2,508,934,000	100.00

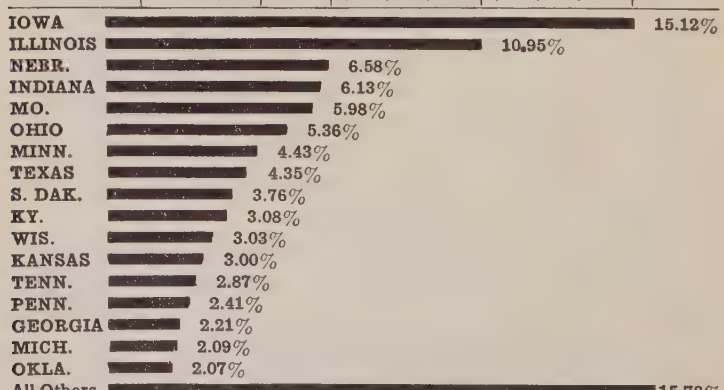

Figure 15.—The percentage of the crop of the United States produced in the states of greatest production (1918-1922).

cereals, and the product is of greater value than any other crop in the United States. Table IV, which shows the average acreage, yield, and farm value of some of the leading farm crops during the five years from 1918 to 1922, inclusive, effectively illustrates their relative importance.

Table IV. Average acreage, production, and farm value of the leading crops in the United States during the five years from 1918 to 1922, inclusive.

Crop	Area	Production	Farm value
	Acres	*Bushels*	*Dollars*
Corn	101,901,000	2,896,366,000	2,508,934,000
Hay	58,144,000	(a) 85,988,000	1,410,477,000
Wheat	64,189,000	878,712,000	1,355,624,000
Cotton	33,941,000	(b) 10,964,000	1,293,669,000
Oats	42,677,000	1,302,454,000	683,411,000
Potatoes	3,953,000	390,173,000	425,826,000
Tobacco	1,742,000	(c) 1,376,262,000	365,543,000
Barley	7,773,000	186,846,000	142,158,000
Sweet potatoes	1,021,000	99,433,000	107,719,000
Grain sorghums	5,180,000	109,151,000	105,597,000
Rye	5,569,000	76,817,000	84,881,000
Rice	1,099,000	42,447,000	65,126,000
Beans	1,094,000	10,395,000	48,927,000
Peanuts	1,276,000	(c) 799,316,000	47,224,000
Flax	1,517,000	10,715,000	25,842,000
Buckwheat	779,000	14,741,000	18,178,000

(a) tons; (b) bales; (c) pounds.

Another basis on which the importance of the corn crop in the various states may be judged is by the proportion of the improved farm acreage which is annually planted to it. Figure 16 shows graphically the percentage of this acreage which was planted to corn during the five years from 1918 to 1922 in the five states of largest production. Corn occupied 20.26 per cent of the improved farm land in the United States, as compared with 12.56 per cent in wheat and 8.48 per cent in oats. In Illinois and Iowa corn is planted on more than one third of the improved farm land, while in several other states it is grown on more than one fourth. These figures are based on the average annual acreage of

the various crops in the five years from 1918 to 1922, as reported by the Bureau of Agricultural Economics, and on the acreage of improved farm land reported in 1920.

61. Acre Yield. The average yield of corn to the acre, even in the best corn states, is very low in comparison with known yields in any community. The states showing the highest average yield are those with comparatively small acreages. The five states showing highest acre yields in the five years from 1918 to 1922 are Connecticut, with an average yield of 47.4 bushels; Maine, 47.2 bushels; Massachusetts and New Hampshire, 46.5 bushels; and Pennsylvania, 44.8 bushels to the acre. The surprising fact is that in the north-

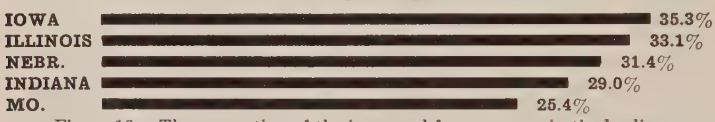

Figure 16.—The proportion of the improved farm acreage in the leading states which is annually planted to corn (1918-1922).

ern states, where small varieties are grown, the yield is considerably more per acre than in the Central and Southern states, where larger varieties thrive. The South, however, owing to the longer season and more abundant rainfall, has greater possibilities in corn production than can be found in the North, and yields there of over 200 bushels per acre have been obtained on specially prepared and fertilized land. The possibilities for increased yields are great in any part of the United States, and even in the northernmost states yields of 100 bushels and over are sometimes produced.

62. Units of Measure for Farm Crops. Over a very large part of the United States the unit of measure for the cereal crops is the bushel of 2,150.42 cubic inches capacity, but as these crops vary in weight per bushel and as their values are more accurately measured by weight than by bulk, a more accurate comparison of production and value may be made by use of the unit of measure now common in the western states, the pound or hundred pounds. It would

be a desirable change for all concerned if it could be agreed to discard the bushel as a unit of measure and substitute the actual weight of the crop.

To show the value of this change, only a few illustrations of its convenience are needed. As most of our cereals are used at times for feed, the question often arises, which is it more economical to feed and which to sell? If oats are selling at 60 cents per bushel of 32 pounds, and corn at 98 cents per bushel of 56 pounds, it is a somewhat complicated problem to determine just what is the relative price of the two crops. If the same problem were to arise and the relative prices were the same, with 100 pounds as the unit of measure instead of the bushel, it would be stated as follows: Oats, $1.87\frac{1}{2}$ per cwt.; corn, $1.75 per cwt. The comparison is instantly and accurately made without computation. Another problem that often arises on the farm is to determine the advisability of increasing or decreasing the relative acreages of some of the cereal crops. A comparison by bushels is certainly unfair, if feed is the object of the crop. If one knows that barley has been yielding about 25 bushels, oats 35 bushels, and corn 30 bushels to the acre, one is likely to have a different idea of the relative importance of the crops than one would if the yields were stated in pounds to the acre as follows: Barley, 1,200 pounds; oats, 1,120 pounds; and corn, 1,680 pounds.

SOILS AND FERTILIZERS

63. Soils. Corn grows best in warm, rich, moist, well-drained sandy loam soils. It should not be inferred, however, that this crop will not thrive on any other kind of soil, because it will grow and is grown on soils of almost every type. It will grow on very light, poor land, but it makes really good growth only on deep, rich soil. It is a strong feeder, and can make use of coarse manure and soddy land better than most other field crops.

To be reasonably sure of success, corn land must be sufficiently well drained to allow a free circulation of air in the soil to a depth of from 2 to 3 feet, must have enough plant food available for the production of ordinary field crops, and must be situated where there is a sufficient period of time free from frost to allow the crop to mature. A higher average temperature must prevail than is necessary for some of the small grain and grass crops. The soil must be compact enough to retain moisture, yet should be fine and mellow enough so that the roots may easily penetrate it.

The corn plant in its growth uses large amounts of moisture. Corn can hardly be termed a dry-land crop, as it must have a reasonable supply of moisture to succeed, but it can be carried over periods of drought of considerable length by persistent cultivation to check evaporation. The soil, however, must have contained a good supply of moisture before the beginning of the drought. The only reason corn can stand dry weather better than the small grain crops is because cultivation is possible during its growth, lessening the evaporation from the soil.

64. The Application of Manure. As corn is a gross-feeding plant and is able to make good use of such sources of plant food as manure, it is the general practice to apply barnyard manure to the corn crop, usually before the land is plowed. As the greater part of the available manure is produced during the winter, plowing is generally deferred until spring, so that all the manure may be put on the land. Plowing under coarse stable manure, whether on sod or stubble land, is objectionable from the standpoint of moisture control and probably also in the matter of getting the best use of the manure. The coarse manure lying between the subsoil and the furrow slice quite effectively separates these two portions of the soil and retards the movement of moisture between them. Much better results can be obtained if the land thus manured is thoroughly disked and the manure

incorporated in the top soil before plowing. Doing so aids in settling the furrow slice firmly against the subsoil.

65. Applying Manure to Grass Land. A better practice than the one just mentioned is to apply manure to the grass land a year or more before the land is to be plowed for corn. Manure applied to pasture land greatly stimulates the growth of grass. By trampling and by natural decomposition, it becomes somewhat mixed with the surface soil and incorporated with it; then, when the land is plowed, it does not act as a coarse mulch to separate the plowed portion from the subsoil. This method of applying manure has the additional advantage of disposing of most of the weed seeds which are commonly present in it. Weed seeds in manure thus applied are induced to germinate, but the plants are unable to make much growth and have little opportunity to produce seeds in either meadow or pasture.

66. Applying Manure as a Top-Dressing. Another very good practice that is being followed more and more by corn growers is to apply the manure to corn land as a top-dressing. This practice makes it possible to plow the land in the fall. Manure accumulated about the yards and produced in the stables during the winter is spread on top of the fall plowing and is disked into the soil in the spring before the corn is planted. In this way the coarse manure which is applied does not in any way tend to separate the surface soil from the subsoil. It helps to form a surface mulch to retard the evaporation of moisture from the soil, and it is near the surface where many of the weed seeds in it may be germinated and the plants easily killed by subsequent cultivation. It is above the roots of the plants, so that leaching from the manure carries the fertility down to the plant roots, instead of carrying it below and out of their reach as may be the case if manure is plowed under.

From ten to fifteen loads of manure to the acre, which is as much as it is generally advisable to apply at one time, may

be disked into the surface of fall-plowed land so thoroughly as to give little or no trouble in the planting and cultivation of a corn crop.

67. Use of Green Manure Crops. In the South and East, where less stable manure is available than in the corn belt,

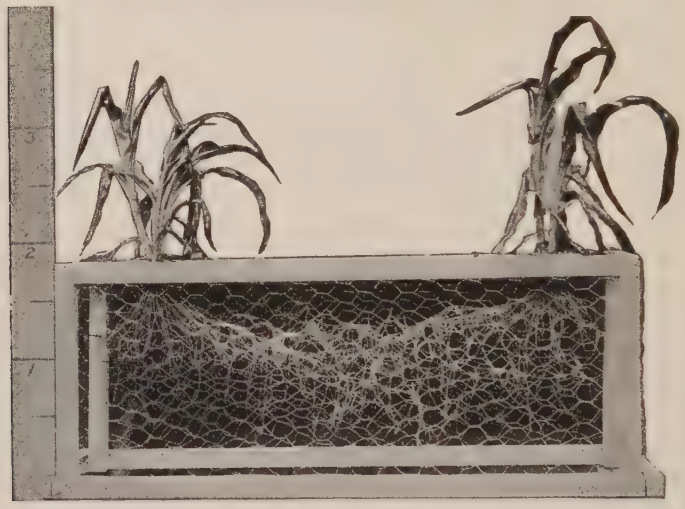

Figure 17.—Hills of corn six weeks from planting. Note how the surface 18 inches of soil is filled with roots. The soil must be well prepared for this rapid growth of roots.

while the need of adding fertility and vegetable matter to the soil is greater, the use of green manure crops before planting corn is generally beneficial. Where corn is planted on sod land, plenty of vegetable matter is available, but such land is not common in the South. In that section, the vegetable matter can best be supplied by the use of cowpeas, soy beans, velvet beans, crimson clover, bur clover, or some crop of similar nature. The green manure crop should be plowed under some time previous to planting corn, so that the land has time to settle and the vegetable matter to decay to some extent, but it is usually better to plow in the early

spring than in the fall. Leaching and washing, which are very likely to take place on fall-plowed land, are prevented by a cover crop which is not plowed under till spring.

68. Commercial Fertilizers. While a leguminous green-manure crop such as those suggested in the previous paragraph will supply nitrogen it is usually necessary throughout the East and South to supply some phosphorus and potash to meet the demands of the corn crop. Quite frequently, a complete fertilizer which contains all three of the elements just mentioned is used. The fertilizer is quite commonly distributed along the row in two applications, the first when the corn is about 2 feet high and the second just before it tassels, though sometimes it is all applied either broadcast before or in the row at the time of planting. The fertilizing materials generally used are cottonseed meal, muriate of potash, and acid phosphate. The quantity which is applied and the proportions of the three constituents vary greatly with the soil on which the crop is grown[1]. The usual quantity of the mixture ranges from 300 to 500 pounds, about two thirds of which is put on at the first application. A good corn fertilizer should contain about 8 per cent of phosphoric acid, 5 to 6 per cent of nitrogen, and 5 to 9 per cent of potash. It is not usually profitable to use commercial fertilizers in the corn belt where there is plenty of vegetable matter in the soil, though on some soils which are decidedly deficient in some one element, marked benefit is obtained from it.

PREPARATION OF THE SOIL

69. Preparation of Fall-Plowed Sod Land. The ability of corn to use plant food in a crude form makes it possible to plant it on newly broken sod land. It frequently follows clover or some other hay crop, or is planted on a field that has been in pasture. Such crops leave the land some-

[1]While the price of fertilizer is now (1923) much lower than during the war, yet the relatively low prices of most farm products require the more general use of green and barnyard manures for economy.

what soddy, so that considerable preparation is required to make a good, hospitable seed bed for corn.

Sod land is best prepared for corn if it can be plowed in the fall, so that there is some opportunity for it to decompose before the crop is planted. There is also time for the part turned by the plow to settle sufficiently to establish connection with the subsoil, so that in case of a shortage of moisture the supply in the lower layers of soil may be drawn up to the plants growing in the furrow slice. The freezing and thawing of the winter season tends to break down the unusual porous structure to its natural condition.

Land plowed in the fall should be disked or harrowed early in the spring to check the evaporation of moisture from the surface. Harrowing aids in warming the soil by checking the evaporation. It also causes many weed seeds to germinate. The young plants can then be killed by later harrowings before the crop is planted. Much of the advantage in plowing corn land in the fall may be lost by neglecting to harrow early in the spring. If the land is left rough and has settled clear to the surface, as is usually the case in the spring with fall-plowed land, evaporation goes on very rapidly; and, as corn is not usually planted for several weeks after the ground thaws in the spring, there is opportunity for the loss of much moisture. It is desirable to disk or harrow this land at least once every week till planting time. In preparing a seed bed for corn the object should be to have the lower part of the furrow slice thoroughly pulverized but compact enough to permit the free movement of water by capillarity, while the upper part should be loose enough to retard the evaporation of moisture somewhat by preventing its easy rise to the surface, where it will be quickly drawn out by the sun and wind.

An additional advantage of fall plowing, especially in the case of sod land, is that many insects are destroyed which might otherwise cause considerable injury to the crop.

70. Preparation of Spring-Plowed Sod Land. A large part of the land that is planted to corn must, for various reasons, be plowed in the spring. To get the best results from spring plowing, the conditions obtained by fall plowing must be duplicated as nearly as possible. One of the chief difficulties with spring plowing is that the soil does not have a chance to settle; it is, therefore, likely to be so loose that it dries out readily, while at the same time the movement of moisture from the subsoil up through the furrow slice is somewhat retarded. One of the most common ways of putting spring-plowed land in the desired condition is to harrow and disk it several times after plowing to aid in packing it. The surface of spring-plowed land is easily pulverized, especially if it is harrowed soon after it is plowed. For this reason, a spring-plowed field may appear, from the surface, to be in excellent condition, when in reality it is in very poor condition, as the surface may be thoroughly pulverized and the lower part of the furrow slice still improperly

Figure 18.—Hills of corn eleven weeks from planting. The roots have now penetrated to a depth of 2½ feet. Compare with Figures 17 and 19.

pulverized and packed against the subsoil. The earlier the plowing is done the more readily the wet sod will be broken up. Considerable disking and harrowing is necessary to prepare a spring-plowed field for corn. A practice that is followed by many careful farmers is to disk the land thoroughly before plowing. The pulverized surface, when turned over, is more readily compacted against the subsoil than land which is not pulverized. This contact is especially necessary in sod land, for the stubble and other vegetable matter on the surface of meadow or pasture land are liable to separate the furrow slice quite effectively from the subsoil, thus greatly retarding the movement of moisture.

Figure 19.—Hills of corn at maturity. Note that the roots have now penetrated to a depth of 4 feet. See Figures 17 and 18.

Cultivation can be done more cheaply and more completely before the corn is planted than afterwards, because more horses and larger machines can be used and all the soil can be cultivated to better advantage.

71. Preparation of Stubble Land. The methods outlined for the preparation of sod land for corn will produce

equally good results when applied to ordinary stubble fields. The only difference is that such lands are usually more easily prepared than sod lands.

PREPARATION OF SEED CORN FOR PLANTING

72. Good seed is equally as important as a well-prepared seed bed. Good seed corn is seed from a variety

Figure 20.—Grading seed corn makes it possible for the planter to drop the seed uniformly. A, the ungraded sample; B, the large, uniform kernels for planting; C, the small and irregular kernels graded out.

adapted to one's needs and conditions, of strong germination, and sufficiently uniform to insure even planting. For the selection of seed corn see Sections 121-132.

73. Grading. The first step necessary in the spring to obtain good seed is to select ears of corn from the supply at hand that are as uniform in type of ear and kernel as it is possible to get. Corn is generally planted with machines. These machines can plant uniformly only when kernels of uniform size are used. Two ears of corn may be good indi-

vidual ears, but, if the type of kernel is different, when they are shelled together they will make an uneven sample of corn which cannot be planted uniformly. Likewise, kernels of corn from the tip and butt of the ear, if shelled with the more uniform kernels in the middle, make an uneven mixture which no machine planter can plant uniformly. If a corn grader is at hand through which corn may be run and the small, large, and irregular kernels removed from those which are of a uniform type, it is not so important that uniform ears be selected, or that the tip and butt kernels be removed. If such a machine is not at hand, as is the case on the majority of farms, it is highly important that uniform ears be chosen and that the tip and butt kernels be removed from these ears before the bulk of the corn is shelled for seed. If this is done, a reasonably uniform sample may be obtained.

Figure 21.—Tip, middle, and butt kernels. Tip and butt kernels should be shelled off from the seed ears and discarded, as they are irregular in shape and will not drop uniformly.

74. Germination. Experiments conducted by a number of experiment stations indicate conclusively that there is a very close relation between the stand of corn and the yield. This being true, it is of great importance that only such seed as is known to be of strong germination be planted. If 100 kernels from a uniform sample of corn are taken and each of the 100 kernels grows, producing a strong, vigorous shoot and strong roots, it is reasonable to suppose that the sample is good; but if only 90 out of the 100 kernels grow, the sample is of questionable value, because, if such seed is planted, it means that one acre out of every ten planted will not produce anything.

75. The Individual Ear Test. Instead of making the test from a bulk sample of corn, as suggested above, the best

growers now recommend and practice the testing of each ear of corn as to its germinating power, before it is shelled, and, if it does not germinate strongly, it is discarded. There are numerous ways of making this test, which are all good.

To make the test, some method of numbering each individual ear must be used. There are several different ways of numbering the ears, among which are the following: (1) The ears may be placed on a seed-corn tree (Figure 42) and a number placed on the tree near each one of the nails. (2) If the corn is hung up by the double-string method (Figure 43), the ears may be numbered without taking them out of the strings by numbering one string 1, the next string 11, the next 21, and so on, assuming that there are ten ears in each string and that the ears in the string are numbered from 1 to 10. If there are 13 ears in each string, for example, the second string is marked 14, the third 27, and so on. (3) Another method of numbering is to lay the ears side by side on a plank and drive a tenpenny nail between each two ears. In this way each ear of corn will be separated from the next by a nail, and the number may be written just beneath each ear with a piece of lead or pencil.

76. The Rag-Doll Tester. Probably the simplest method of testing seed corn is with what is known as the rag-doll tester. To make this tester, take a strip of bleached muslin about 16 inches wide and from 3 to 5 feet long. Begin 6 inches from one end and mark it off in 4-inch spaces; then draw a line lengthwise through the center of the strip, dividing each of these spaces in two. Now number the first two 4-inch spaces 1 and 2, the next two 3 and 4, and so on to the end. Moisten the muslin and lay it flat on the table.

77. Making the Test. Take 6 kernels from ear 1 and place them in space 1 with all the tips pointing to one side; then take 6 kernels from ear 2 and place them in space 2, and so on. As long a strip of muslin may be used as can be conveniently rolled. The spaces may be made slightly

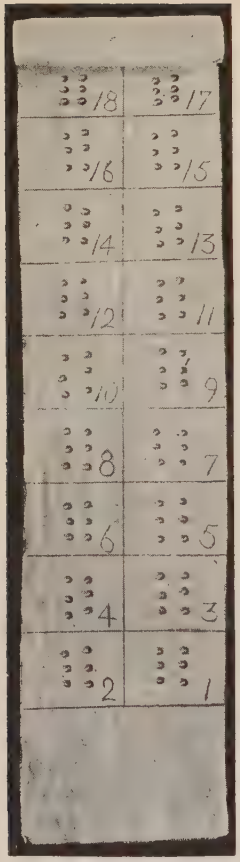

Figure 22.—Rag-doll seed corn tester showing seed placed in separate sections.

smaller if desired. Press the moist muslin down on the kernels. Next begin at one end to roll the strip, either making a roll of the cloth alone or rolling it over a cob or small, round stick (Figure 23). Tie the completed roll in the middle with a string or fasten it with a rubber band. Soak it in lukewarm water three or four hours, then let it drain, and place it where it will remain moist and warm. Ordinary room temperature of about 70 degrees is all right, though germination will be more rapid if it is kept at about 80 degrees during the day. If, however, one wishes to make a very selective test, it would be well to keep the temperature down to that of probable field conditions at the time of planting. More marked differences will then be apparent in the sprouts. The higher the temperature the more likely even the poorer kernels are to develop fair sprouts. Keep the roll moist by covering with wet cloth or by moistening occasionally, as may be found necessary, but do not soak it again. At the end of 5 days unroll the

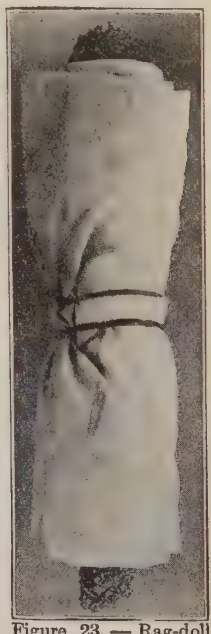

Figure 23. — Rag-doll seed corn tester rolled around a corncob.

doll carefully so as not to mix the kernels from the different ears, count the kernels which have germinated strongly in each space, make a record of the results for each ear, and discard all ears which do not show at least 5 strong sprouts from the 6 kernels. If seed corn is plentiful and of good quality, save only the ears which show strong sprouts from all kernels. When a person has a variety of corn known to be adapted to his conditions, has selected and graded it till the kernels are uniform, and has tested the germination and discarded all that did not germinate approximately 100 per cent, he has good seed.

Figure 24. — Germination of corn kernels. The one at the left has the tip shoot only; the one in the center, the root; only the one at the right, with both root and tip strongly developed, will produce a strong plant.

PLANTING CORN

78. Important Factors in Planting. There are four points of importance to consider relative to planting corn. The first of these is the time of planting; second, depth of planting; third, method of planting; and fourth, thickness of planting.

79. Time of Planting. The time of planting corn varies with the season and the location. Corn is a semitropical plant which will not stand frost; on this account, it must not be planted until the season is quite well advanced or until danger of frost is past. Corn planted in cold, wet ground does not do well, and seed that would normally germinate and grow strongly may be entirely lost if planted when conditions are not suitable. Generally, it is safe to delay planting until there is every indication of favorable conditions of

soil and weather. Corn planted May 20 may easily outstrip in growth and yield that planted under less favorable conditions ten days earlier.

It is quite obvious that no definite date for planting can be set, even for one locality, and much less for the United States. It is usually well to plant as early as soil and weather

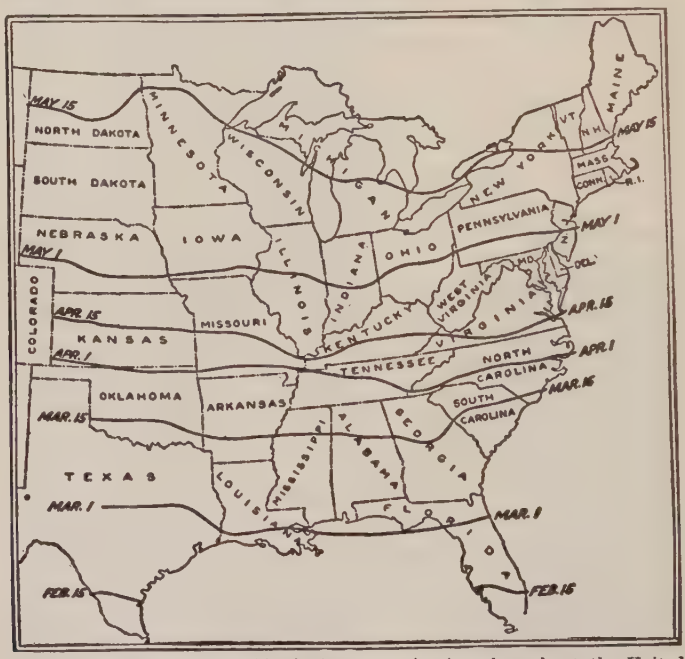

Figure 25.—Average dates of beginning corn planting throughout the United States.

conditions will warrant. The date will naturally vary in different parts of the United States, from March in the South to June in the extreme North. The accompanying map, Figure 25, shows the average date when corn planting is begun in the various sections, as compiled from a large mass of information on this subject collected by the Bureau of Crop Estimates of the Department of Agriculture.

80. Depth of Planting. As corn thrives best in a warm, moist soil, it is obvious that rather shallow planting will be most likely to furnish the best conditions at the season of the year that corn is usually planted. The depth must necessarily be varied with the condition of the soil. The seed must be planted deep enough so that it can get sufficient moisture to germinate, but it is not necessary or desirable to plant it deeper. On light or very loose soils, it should be planted deeper than on heavy soils. On soil that has been well prepared, it should not be necessary to plant deeper than 2 inches to get sufficient moisture, and 1 inch is to be preferred, if there is enough moisture present.

Figure 26.—Planting corn with the check-row planter. Long, straight rows make the work of cultivation easy.

In some of the drier sections of the corn belt, listing is practiced. Listing is planting corn in the bottom of a furrow from 3 to 5 inches deep and covering it with only 1 or 2 inches of soil. As the corn grows and the field is cultivated, the soil is gradually thrown in about the plants. This method is not advisable except in very dry locations, for experiments have shown that even in regions of light rainfall corn planted in the usual way has given larger yields than listed corn, except in the very driest seasons.

81. Method of Planting. There are two common methods of planting corn for the production of grain. The first is in checked rows, with hills 42 or 44 inches apart each way. The second is in drills 42 or 44 inches apart, with the kernels of corn dropped in the drills from 9 to 18 inches apart. Some good corn growers follow one method, some the other. Those

who advocate drilling corn claim that less cultivation is required, and, because the corn is better distributed, larger yields are obtained. The facts do not seem to bear out this contention, though on specially clean soil and in years when the rainfall is normal or more than normal, slightly larger yields have been obtained from drilling. In a large number of tests conducted by several experiment stations, however, there has not been sufficient difference in yield to warrant advocating one method above the other.

One of the objects in growing corn is to clean the land of weeds. This certainly can be more thoroughly accomplished if the corn is planted in checked rows and cultivated both ways than if planted in drills; on this account, it is deemed advisable, on most soils, to plant in this manner. It is also easier to husk hill corn than drill corn; but, if it is to be fed out of the bundle, the advantage of the larger number of small ears is in favor of drilling. On rich soils, such as clover sod, that are comparatively free from weeds, drilling corn may give very good satisfaction, especially if the land is thoroughly prepared before the corn is planted. On hilly or broken land it is also often advisable to plant in drills to prevent washing of the soil and to avoid the difficulty of short turns in cultivation. It is generally better, however, to plant corn so that it may be cultivated both ways.

82. Thickness of Planting. The general practice in planting corn is to plant in hills 44 inches apart, with three kernels to the hill; or, if planted in drills, to use about the same quantity of seed. It has been shown by numerous tests throughout the corn belt that a stand of three stalks to the hill, as a rule, gives about as large yields as can be expected. Where tests have been made with two, three, and four stalks to the hill, the yields have been slightly larger with four stalks than with three, and much larger with four or three than with only two. From these experiments, it is quite safe to plan on at least three stalks to the

hill, while four stalks are preferable to three. A six-year experiment in Nebraska showed that with one plant in a hill, there were 161 ears on 100 plants and a yield of 48.3 bushels per acre, while the maximum yield per acre, 76.7 bushels, was obtained when there were four plants in a hill and when the number of ears per 100 plants was only 82. If the quality of seed is in doubt, four kernels should be planted in each hill instead of two or three. From 4 to 7 quarts of seed are required to plant an acre. In dry sections and on poor land thin planting is desirable.

A large number of tests to determine the distance apart to plant corn have shown that slightly larger yields are obtained by putting the rows more closely together than is the common practice. A test made by the Illinois Agricultural Experiment Station for two years shows a yield of 58.3 bushels to the acre when corn was planted 39½ inches apart each way with three kernels to the hill, as compared with 53.9 bushels from hills 44 inches apart each way, three kernels to the hill. The increased yield from the closer planting in this case was a little more than sufficient to cover the increased cost of growing corn in hills 39½ inches apart each way over that in 44-inch hills. With some smaller varieties grown in the North, better results can be obtained by planting from 36 to 40 inches apart each way than planting 44 inches each way. In the corn belt, however, it is evident that the practice of planting corn in checked rows 44 inches apart, with three to four kernels to the hill, can hardly be improved. On poor land in the South it is not uncommon to plant corn in rows as wide as 5 feet apart.

83. Types of Planters. Corn is often planted in small patches by hand, using a hoe to open the hills and to cover the kernels after they have been dropped. This method of planting is very slow. Hand planters are sometimes used but they are very inferior to the two-row horse planter which is the implement always used where any considerable acreage

of corn is grown. From 12 to 18 acres may be planted in a day by one man and two horses with a two-row planter. Most of these planters may be used for either checking or drilling corn. There are two types of horse planters. In the round-hole type, the desired number of kernels to the hill is regulated by the size of the holes in the disks or planter plates used; in the other, the edge-drop planter, the number of kernels to the hill is regulated by the number of places in the edge of the disk, each of which will permit one kernel to enter edgewise. The edge-drop planter is more accurate than the round-hole planter if the seed corn used is all graded to a uniform size, but with irregular kernels of corn the round-hole type is to be preferred.

CULTIVATION

84. Objects of Cultivation. The objects of cultivating corn are to conserve moisture, to liberate plant food, and to destroy weeds. As previously stated, (Section 70), it is cheaper to do as much of the cultivation as possible before the crop is planted. The labor of keeping a field in good condition during the growth of the crop is thus greatly reduced.

85. Harrowing. There is considerable difference of opinion as to the advisability of harrowing corn land after the crop is planted. During the first day or two after planting, it may be harrowed without danger of injury, but as soon as the kernels begin to germinate there is danger that the harrow teeth will destroy some of the young plants.

It seems somewhat inconsistent to spend considerable effort in grading and testing seed corn to insure a perfect stand and then take the risk with the harrow to destroy from 5 to 10 per cent of the plants at one operation. One can hardly set any hard and fast rules for the care of corn, because so much depends on the soil and especially on the weather conditions; but, if planting is deferred until conditions are favorable and the seed is planted only on soil that

is in thoroughly good condition, harrowing normally will be unnecessary. If cold, rainy weather comes on after the corn is planted, however, preventing its prompt germination and growth, it is probably better to harrow the field and keep the soil in good condition than to allow it to become baked and hard and to permit weeds to grow, even if some plants are destroyed by this treatment.

86. Blind Cultivation. In many instances, blind cultivation,—that is, cultivating the corn before it is up by following the rows, as indicated by the planter marks,—is a desirable practice. By cultivating as soon as it is evident that the soil should be stirred, even throwing a little soil on top of the row, its condition may be greatly improved and many small weeds may be destroyed without injuring the small corn plants. Thus harrowing can often be obviated.

87. Use of the Weeder. The weeder is often used during the early stages of cultivation with good results. The weeder is such a light implement that unless the soil is in fairly good condition it cannot do much work; but if the soil has been harrowed, or preferably, blind-cultivated, going over it with a weeder will destroy many small weeds and leave the soil soft and mellow on top of the hills, so that the plants can easily push their way out.

88. Types of Cultivators. The selection of tools for the cultivation of corn may be influenced to a considerable degree by personal preference. A few simple principles are worthy of consideration in the selection of these implements, however. A cultivator is used to loosen the soil, sometimes when it is rather heavy and hard, and also to tear out rather large weeds which should not be in a corn field, but which, nevertheless, are often found there. It is evident, then, that a cultivator, to be useful for these purposes, must have strength capable of stirring considerable soil to a reasonable depth.

The types of sulky cultivators in more or less common use include those with two shovels on each side, the shovels

necessarily being large to cover the ground; those with three shovels on each side, the individual shovels somewhat smaller but still comparatively large; and those with four or more rather small shovels on each side. There are also disk cultivators and the so-called surface cultivators with flat blades instead of shovels set diagonally and run just under the surface of the ground.

89. Uses of Different Types. It is evident that some of these types of cultivators are better adapted to some conditions than to others, and that all have their place. It is also evident that the number of shovels, the size of shovels, their arrangement, and the way they pass through the soil have much to do with the clogging of the gangs by weeds or other refuse that may be in the soil. Clogging and inability to tear up heavy, weedy soil are some of the objections to cultivators having several small shovels on each side. Those having two or three rather large shovels are objectionable chiefly because, in order to stir thoroughly all the ground over which they pass, it is often necessary to run the shovels deeper than is desirable, with the result that the corn roots are injured. Surface cultivators are ideal so far as avoiding root injury and keeping weeds cut off below the surface are concerned, but are not as efficient as the shovel types in loosening the soil, in working very weedy land, or where there is much coarse manure. On this account, it appears that for general work on the farm a cultivator with three or four moderate-sized shovels on each side, set diagonally so they are not likely to be clogged with weeds or refuse, is the more desirable type of implement for general use. If a combination machine can be had, on which blades for surface cultivation and sets of shovels can be used as desired, a still better implement is available.

90. Two-Row Cultivators. In recent years, many of the larger corn growers have used the two-row cultivators. These are certainly economical, as where the soil is well prepared and the planting well done, a man can handle such

a machine practically as well as he can a one-row cultivator, thus considerably reducing the cost of cultivation.

91. One-Horse Cultivators. To complete any equipment for corn cultivation, a fine-tooth, one-horse cultivator should be available for use after the plants are too high to cultivate with the ordinary tools. The surface mulch made by

Figure 27.—The two-row cultivator, an economical implement for use in large fields that have been well prepared.

the early cultivation given is often entirely eliminated by a heavy rain; then, in order to save the moisture needed for the later development of the crop, the surface of the soil must be stirred. This cultivation can best be done with a fine-tooth, one-horse cultivator that stirs the surface thoroughly and yet not so deep as to injure the roots.

92. Depth of Cultivation. It is impossible to state any arbitrary depth at which it is desirable to cultivate corn. The object of the cultivation should be to leave the soil in a loose, mellow condition on the surface and to destroy any weeds that may be growing, with as little injury as possible to the corn roots. Anyone may convince himself, by careful observation, that the roots of corn quite thoroughly occupy

the entire soil area between the rows by the time the plants are 12 to 15 inches high (Figure 17). As the roots are the chief means the plant has of obtaining plant food and moisture, it is plain that to injure any of these roots lessens the feeding area and the food supply of the corn plant.

Corn roots or, in fact, the roots of any plants, are sure to grow in the portion of the soil that furnishes the best conditions for their growth. In wet years, when the soil is saturated with moisture, there is likely to be a scarcity of air in the soil; hence the roots of plants will grow quite near the surface. In dry years, when there is a scarcity of moisture, especially in the surface, the roots will grow deeper in search of moisture. It is thus evident that it is safe to cultivate more deeply in dry years than in wet ones. The depth to which the field has been plowed also influences the depth at which roots will grow most abundantly.

The depth of cultivation should always be regulated by the depth at which the corn roots grow and by the necessity for deep cultivation, such as weeds or a heavy, wet condition of the soil. If deep cultivation must be practiced, it is safer to cultivate deep while the corn plants are small. They then have smaller root systems and are injured less by having some of the roots broken off. The practice followed by the best corn growers at present is to cultivate deep at the first cultivation, if deep cultivation is necessary at all, and then to cultivate as shallow as is consistent with keeping the soil in good condition and free from weeds.

93. Frequency of Cultivation. If care is exercised not to disturb the roots of the corn plant, cultivating often enough to keep down weeds and to maintain a good surface mulch to retain moisture is desirable. The soil can usually be kept in good condition by cultivating three or four times, but sometimes six or even eight times is more profitable.

The impression used to be quite general that it was not advisable to cultivate corn after it had tasseled. There

were two principal reasons for this belief: First, sulky cultivators cannot well be used at that time; second, corn growers, not realizing the loss that might come from cutting off corn roots, found that cultivating the corn after it had reached that state usually resulted in injury rather than benefit to the crop. It has now been quite definitely shown that this

Figure 28. — Husking corn from the standing stalks, the usual method of harvesting.

injury was due to the cutting off of roots and to no other reason. Many good corn growers now find it very profitable to go through their corn fields quite late in the season with a one-horse, fine-tooth cultivator and stir the surface soil quite thoroughly, thus retarding evaporation and giving the corn a larger supply of moisture at the time it is most needed; that is, when it is forming ears. If care is exercised not to cut off the roots, it is perfectly safe to cultivate corn at any time during the growing season.

HARVESTING CORN

94. Picking. A large percentage of the corn grown in the corn belt is harvested by picking the ears from the standing

stalks, leaving the stalks in the field to be pastured off by stock or to be cut up and plowed under. Corn is usually picked by hand. One man uses a team and wagon with high "throw board" on one side of the wagon box; the team is driven through the field astride one row, and the man picks

Figure 29.—The corn picker, a machine for gathering the ears from standing corn. Not yet in general use.

the two rows at the side of the wagon, the team stepping ahead slowly as the husking progresses. The high board on the opposite side of the wagon aids the husker in striking the box. From these wagons the corn is shoveled into cribs, where it is stored until used. In the South, the ears are simply snapped from the stalks, the husks being left on to protect the grain from insects.

During the last few years, machine pickers have been invented and are now in use to some extent. These machines must be driven over each row of corn; a set of rolls pulls off the ears and takes off the husks; the husked ears are then elevated into a wagon which is driven beside the husker as it

goes across the field. These machines, of course, cannot husk corn under all conditions as clean as it can be done by hand, but they reduce the man labor required and make it possible to get out large acreages in a short time.

95. Storing Corn. Corn cannot be stored in the same manner as other grains, on account of its liability to heat. It is practically impossible to store a large quantity of it together until it is at least a year old, without great danger of its heating and spoiling.

The most common method of storing corn is in the corncrib, a narrow bin with slatted sides so that air can circulate freely through it. Two and one half cubic feet of space are required for a bushel of corn on the ear, which is the form in which it can most safely be stored. If 40 acres of corn are produced on a farm of 160 acres and storage room must be provided for 30 acres with a yield of 50 bushels to the acre, 3,750 cubic feet of space are required. To furnish this space, four cribs 8 feet deep and 20 feet long, 5 feet wide at the bottom and 7 feet wide at the top, would be necessary. If possible, the corncrib should be raised on concrete pillars high enough so that mice and rats cannot readily get into it. The bottom should be tight, to save the corn that will naturally shell off as it is handled, but the sides are commonly made of 1 by 3 or 1 by 4 inch material nailed on to the studding with an inch open space between the cleats. Cribs wider than 6 feet should have some provision made for the circulation of air through the middle. This may be easily supplied by standing three or four posts erect, and placing woven wire around these so as to make a spout up through the center of the crib. The spout may be from 6 inches to 2 feet across and should extend from a hole through the floor of the crib to allow free circulation of air. With these spouts placed every 6 or 8 feet through the center of the crib, it is safe to make the crib from 8 to 12 feet wide. Two or more cribs may be placed under one roof. A common practice is

to place two cribs 12 to 14 feet apart, cover them with one roof, and use the driveway between them for a wagonshed.

96. Handling Bundle Corn. Often corn is not husked, but is fed in the bundle. When it is handled in this way, it is cut with a corn binder (Figure 32) and shocked. It is then either hauled to the yards as it is fed or stacked in very

Figure 30.—Shredding corn fodder and storing it in the barn where it will be convenient for feeding.

narrow ricks. It is impractical to stack corn in large stacks, except in cold weather, as it is likely to heat.

97. Shredded Corn Stover. In some instances, corn that has been cut and shocked is run through machines called shredders, which husk the ears and tear the stalks into fine bits. Cornstalks are not made more palatable by running them through the shredder, but they are made much more convenient to handle and the corn is husked by machine power instead of by hand. The cost of shredding the corn is fully as great as husking the shocked corn by hand. The

advantages of the process are that the work is quickly done and the stover is in better condition to handle, though it is often quite difficult to keep it, as it is very likely to heat or mold if it is not thoroughly dry when shredded.

98. Cost of Saving Corn Stover. It sometimes seems very wasteful to see large fields of corn in which the stalks have been left standing, and where little or no use is made of these stalks. There is considerable value in corn stover, yet it is quite expensive to save it. Experiments conducted in Minnesota show that it costs $11.66 an acre to grow corn where the corn is husked from the standing stalks, and $15.30 an acre where the corn is cut, shocked and shredded. Thus the shredded corn stover costs $3.64 per acre. A fair yield of corn stover is from 1¼ to 1½ tons per acre. If the yield is 1½ tons, the cost per ton would be $2.43. These figures were compiled several years ago; the cost of production of all crops is now (1923) much higher. As compared with clover hay at $8 a ton, corn stover has been shown to be worth but $3 a ton. To make cornstalks or corn stover pay for the cost of saving them, that cost should not be more than three eighths of the value of good clover hay. In a good many instances it is not economy to save the corn stover, but preferable to raise clover hay for feed. When forage is high in price, however, and clover hay is worth from $8 to $12 per ton, it pays to save corn stover.

99. Pasturing Stalk Fields. The practice is very general throughout the corn belt of allowing stock to run in the cornfields after the corn has been husked, whenever weather conditions are favorable throughout the fall and winter. There are some reports of injury to stock by this practice, but it has not been definitely shown that the injury comes directly from the cornstalks, and the practice is still continued even by the very best stockmen and corn growers.

100. Hogging Off Corn. Constantly increasing acreages of corn are being harvested by simply turning hogs into the

field as soon as the corn is ripe and allowing them to gather the crop. This practice may seem very slovenly and wasteful, but careful experiments have demonstrated that pork may be produced economically in this way; that is, that an acre of corn will produce fully as much and usually a little more pork if the hogs are allowed to gather it themselves than if it is husked and fed to them in the yard. If hogs are not turned into too large fields, the waste is not great; in fact, they will usually gather the corn as clean as a man. The better results which are sometimes obtained from this method are due, perhaps, to the fact that hogs are better contented when allowed to run at will in the cornfield than when confined, and also because the corn does not become dry and hard and is, therefore, a little easier for the hogs to masticate than after it has been husked for some time.

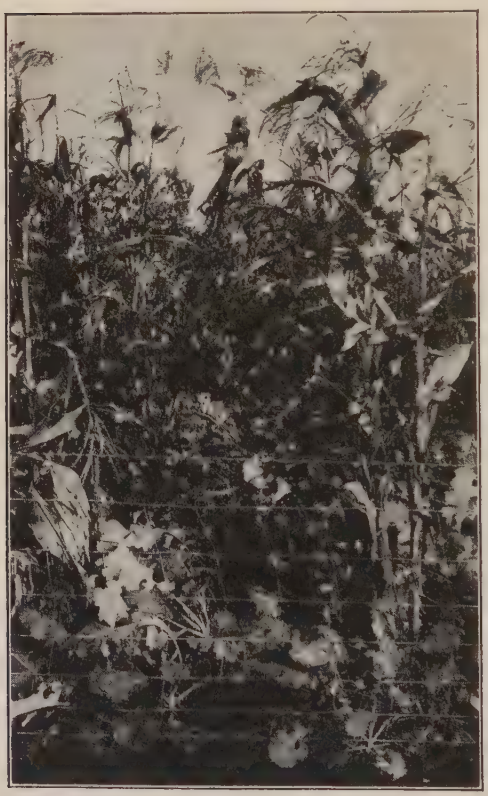

Figure 31.—Rape in corn, a good combination where the crop is to be "hogged off."

When corn is to be hogged off, it is a very common practice to sow rape, cowpeas, or some other crop between the corn rows just previous to the last cultivation of the crop and allow the hogs to pasture the green feed thus produced with the corn. This makes a more balanced ration than the corn alone, and adds to the total feed produced to the acre.

FODDER CORN

101. Definitions. Fodder corn is corn that is grown for the purpose of feeding the whole plant—stalks, leaves, and ears—to live stock. Such corn is usually planted more thickly than ordinary field corn, so that the stalks will be comparatively fine and the ears few and small. Bundle corn is corn that has been grown for ears, but cut, shocked and fed out of the bundle in the same manner as fodder corn is usually fed. Such corn usually has coarser stalks and a larger proportion of ears than fodder corn. Corn stover is the stalks of corn from which the ears have been husked and the stalks left to be fed out of the bundle or shredded.

102. Value of Corn Fodder. Corn is such a thrifty, quick-growing plant that there are few other common crops which can compete with it in the total production of feed to the acre. Owing to its quick, vigorous growth and its palatability, corn is very largely used as a forage crop. Corn fodder, properly grown, is more succulent than corn stover or hay. On this account it is more palatable than these common dry feeds, and is an excellent product to use as part of the roughage for live stock. It is worth $6 a ton for feeding when clover hay is worth $8.80 a ton. A fair yield is from 2½ to 4 tons to the acre. Larger yields are sometimes obtained on very productive land.

103. Importance. So far as its feeding value and yield are concerned, fodder corn is an excellent crop to grow, but on the general farm it does not have a very large place, owing to the fact that it is not a soil-building crop as are clover,

timothy, alfalfa, and the other grasses that are usually grown for forage. On most farms where as much of these grass crops is grown as is advisable in a good system of cropping and where a maximum quantity of corn for grain or silage is produced, there is usually enough roughage so that it is

Figure 32.—The corn binder for cutting corn for fodder or silage. Much corn is also cut by hand or by some form of cutter which does not bind it into bundles.

not necessary to grow fodder corn. It has, however, great value as a catch crop. In years when one has failed to get a catch of grass or when, owing to drought, the hay crop is short, it is often advisable to plant enough fodder corn to insure sufficient roughage to meet the requirements of the live stock kept on the farm.

104. Production of Fodder Corn. Fodder corn will grow on soil that will produce any of the common farm crops, though for its best growth a warm, rich, moist soil is desirable. It is often sown in low places that can not be seeded early in the season. The seed bed for fodder corn

should be prepared in the same manner as for corn that is grown for ears. Fodder corn is usually planted in single or double drills from 36 to 44 inches apart, at the rate of from 20 to 50 pounds to the acre. It may be planted at almost any time in the season up to midsummer, but it is desirable to plant it early enough so that the plants can practically reach maturity before frost.

As fodder corn is usually planted later in the season than field corn, it grows very rapidly and quickly shades the ground. It is, therefore, not generally necessary to give much cultivation. It is a very common practice to harrow the field after it is planted and then cultivate it two or three times until the corn shades the ground sufficiently to check the growth of weeds and retard the evaporation of moisture.

105. Harvesting. Fodder corn is commonly harvested with a corn binder when the crop shows, either by the small ears that it may have produced or by the drying of the leaves, that it is practically mature. If the weather is exceedingly wet, it is sometimes necessary to shock first in small shocks and later to put two or three of the small shocks into one larger one. In shocking, it is desirable to employ some system. It is a good plan to set up two pairs of bundles, all leaning together, then to set bundles around these in a systematic manner until from 12 to 24 have been put into the shock. Care should be used to put approximately the same number of bundles on each side and to set them up firm and snug so that the shock will be evenly balanced and will stand straight. The shocks should be tied securely near the top to help in keeping out the rain and to prevent them from being blown down.

106. Stacking. Owing to the large percentage of moisture contained in fodder corn, it is seldom possible to stack it so that it will keep, except in very cold weather. This fact is one of the objectionable features of the crop. It may be set on end one bundle deep in a mow or shed with perfect

safety, but it is not safe to stack it or to put it in large piles. The method most commonly followed is to reshock in the fields into large, well-made shocks when it is cured and to haul it to the feed lots only as used.

CORN FOR SILAGE

107. Importance. Corn silage is coming to play a more and more prominent part in the economy of the farm. It is well understood that, on account of the important relation of live stock to soil fertility, the highest type of permanent agriculture can be applied on the majority of farms only when a reasonable number of domestic animals is kept. If live stock is to be kept on the farm profitably, it is highly important that it be supplied with an abundance of feed at all seasons of the year and that this feed be as economical as is consistent with good feeding. No feed has yet been discovered that gives better results, under ordinary farm conditions, than that from pastures; but pastures supply feed for live stock only a portion of the year, and can not always be relied upon even then. The next cheapest feed, so far as cost of production is concerned, is clover or alfalfa hay, and these are followed by corn fodder.

Figure 33.—Filling the silo. The whole corn plant is preserved for feeding without waste. The silo is becoming more and more important wherever corn is grown.

Neither pasture nor the ordinary hay crops are as certain to yield profitably as is a well-cultivated corn crop. Stock raisers are rapidly realizing that corn is the most reliable

grain and roughage crop and that the most satisfactory way of storing a good portion of this crop, where it is to be fed on the farm, is by means of a silo. The silo has been shown to help very effectively in cases of shortage of pasture and failure of clover and other hay crops. Corn silage is not only a sure crop, but it is a very palatable, nutritious, succulent feed, that supplies, throughout the winter and during dry times in the summer, much the same feed conditions as are afforded by good pastures.

108. The Production of Silage. Corn for silage may be grown on any good, tillable land, especially any land that is well adapted to the production of an ordinary corn crop. Corn for silage is most commonly grown in the same manner as corn for grain, though those who have had most experience with silage plant about one half thicker, either in drills or in hills, than for ear corn. The cultivation of corn for silage is the same as that commonly given to corn for grain.

The varieties of corn that seem to give best results in the production of silage in a given locality are usually those that give the best yields of grain. As good silage can be made only from corn that is practically mature, it is unwise to use any of the large, coarse-growing varieties in sections where they cannot complete their growth.

109. Harvesting for Silage. When the corn is ripe enough to cut and shock for ear corn, or when the ears are well dented but before the leaves and stalks are dry, it is ready for the silo. It is commonly cut with a corn binder, then loaded on low wagons and hauled at once to the cutter, where it is cut into small bits and blown into the silo. The silo is simply an air-tight receptacle, built strong enough to hold this heavy, green material.

No preservative is applied to silage. It is simply protected from the air, hence it cannot spoil. The surface and any parts that may be exposed, as by a hole in the silo, are quickly sealed over by the molding of a few inches of the corn.

110. Cost and Feeding Value. Statistics gathered in Minnesota show that it normally costs from $18 to $20 an acre, including rent, to grow and store silage. A fair yield is from 9 to 12 tons to the acre. Silage may be fed to all classes of live stock, and is highly prized by all who have had experience with a good quality of it. Compared with clover hay, a ton of silage is worth $4 when clover hay is worth $12. With clover hay at this price, an acre of average corn stored in the silo is worth approximately $40.

111. Stacking Silage. In some parts of the country where silos have not yet been introduced, corn grown for silage is cut and stacked green out of doors with very good results. The stacks are usually made round, with the butts of the bundles out. The ears may be stripped from the outer row of bundles and thrown into the middle of the stack so that the butts can be packed more closely together. The stacks should be made as solid as possible and should be 12 or more feet in diameter and 12 or more feet high. The higher the stacks are, if built so that they will not lean, the better. When these stacks are built they are usually, though not always, weighted down with earth and stones or with patented compressors to facilitate their settling.

The outer part of the stack spoils by molding and thus seals up the inner part and provides the same conditions afforded by a silo. The outer spoiled part is cut off and only the inner part, or good silage, is fed. While considerable corn is wasted by this method, it provides a cheap form of succulent feed and does well until silos may be afforded.

MARKETING AND RETURNS

112. Marketing. Corn is commonly sold from the farm on the ear, though it is sometimes shelled before it is marketed. The usual practice is to sell the ear corn to local dealers, who store it or shell and ship it. Corn is generally shelled before it is shipped, because shelled corn occupies

only about half as much space as the same quantity of ear corn. No treatment is ordinarily given to the grain on the farm; it is sold as it comes from the crib. When shipped from the local buyer to the central market, some of the dirt is taken out in shelling, but no large proportion of it is removed. On account of the method of harvesting, however, corn is usually quite free from weed seeds and other foreign matter. A large part of the crop is fed on the farms or in the communities where it is produced. The average shipments out of the county where it is grown do not exceed one fifth of the crop. Illinois, Iowa, Nebraska, Ohio, and Indiana show the largest percentages of shipments.

The legal weight of a bushel of shelled corn is 56 pounds; of corn on the ear, 70 pounds. If corn is sold within a short time after it is harvested, while it still contains a high percentage of moisture, it is customary to allow 75 or even 80 pounds to the bushel. Ordinary air-dry corn will shell about 56 pounds of grain to 70 pounds of ears, but an extra good sample may shell as much as 60 pounds. Corn that is held over is likely to shrink about 18 per cent.

113. Market Grades. Market grades of corn are fixed by the Federal Bureau of Markets, which divides market corn into three general classes, white, yellow, and mixed. White corn must be at least 98 per cent white by weight; yellow corn must be at least 95 per cent yellow by weight; and mixed corn includes all corn not coming within the limits of the two classes just named. These three classes are then divided into seven grades for each class, known as No. 1 white, No. 1 yellow, No. 2 white, No. 3 mixed, etc. The lowest grade is known as sample grade. No. 1 corn of each class shall be:

Cool, and sweet, shall have a test weight per bushel of at least 55 pounds, may contain not more than 14 per cent of moisture, may contain not more than 2 per cent of foreign material and cracked corn, and may contain not more than 2 per cent of damaged corn and no heat-damaged kernels.

Specifications for No. 2, No. 3, No. 4, No. 5, and No. 6 in each class are similar, differing as follows:

The minimum test weights per bushel are, No. 2, 53 pounds; No. 3, 51 pounds; No. 4, 49 pounds; No. 5, 47 pounds; No. 6, 44 pounds.

The maximum percentages of moisture are, No. 2, 14; No. 3, 15.5; No. 4, 17.5; No. 5, 21.5; and No. 6, 23.0.

The maximum percentages of foreign matter and cracked corn are, No. 2, 3; No. 3, 4; No. 4, 5; No. 5, 6; and No. 6, 7.

The maximum percentages of damaged kernels are, No. 2, 4; No. 3, 6; No. 4, 8; No. 5, 10; and No. 6, 15. Of these, 0.1 per cent may be heat damaged in No. 2 corn, 0.3 per cent in No. 3, 0.5 per cent in No. 4, 1 per cent in No. 5, and 3 per cent in No. 6.

Sample grade corn is any corn which does not come within the requirements of any of the grades from No. 1 to No. 6, inclusive, or which has any commercially objectionable foreign odor, or is heating, hot, infested with live weevils or other insects injurious to stored grain, or is otherwise of distinctively low quality.

Corn of No. 6 grade may be musty or sour; all higher grades must be cool and sweet.

The greater part of the corn which reaches the Chicago market is No. 2 and No. 3 yellow, the quantities of these two grades usually being about the same. Three or four times as much yellow as white corn is marketed in Chicago. The usual difference in feeding value between No. 2 and No. 3 corn is about 2 cents a bushel, but the difference in market price may considerably exceed this figure. The lowest average monthly price of No. 3 Yellow corn on the Chicago market in the five crop market years from November 1917 to October 1922 was 45 cents a bushel in October 1921, while the highest monthly average price was $2.21 in November 1919.

114. Exports. Though the United States produces about three fourths of the world's crop of corn, a very small portion of the crop is normally exported. In the five years from 1917 to 1921, the average annual exportation from the United States was 45,600,000 bushels, while Argentina exported about 90,000 bushels annually during this period. No other country was a considerable factor in the world's trade in corn, the two just named furnishing about 60 per

cent of the entire quantity. The exportation from the United States represents only about 1.5 per cent of the production during the period just mentioned, while the annual exportations since 1901 have not exceeded 4.4 per cent of the crop in any one year. The tendency is for the percentage exported to decrease rather than to increase, except that

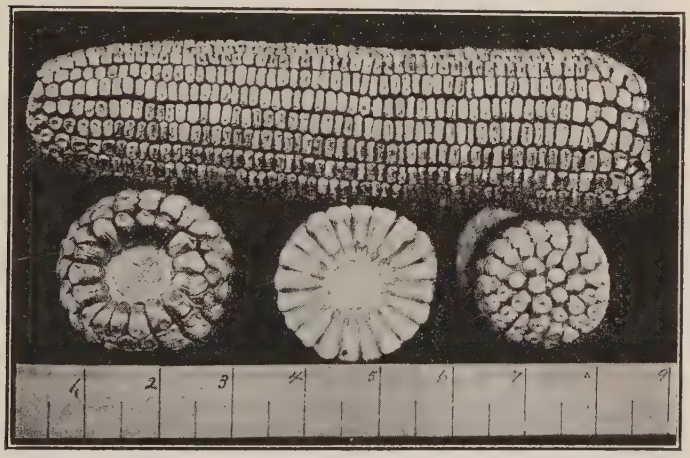

Figure 34.— Reid's yellow dent corn, a large, yellow variety which has been carefully selected for many years.

under war conditions the export demand was greatly increased. The principal ports from which corn is shipped are New York, Baltimore, New Orleans and Galveston.

115. Cost of Production. The best available information on the cost of producing corn is that contained in the April, 1911, Crop Reporter, published by the Bureau of Crop Estimates of the U. S. Department of Agriculture. In this number, the reports of about 6,000 correspondents in all parts of the country are tabulated. The figures are for the cost of producing corn in 1909. The average of all the reports shows that it cost $12.27 to produce an acre of corn in that year; as the average yield was 32.4 bushels,

the bushel cost was 37.9 cents. The items which went to make up this cost of $12.27 to the acre were: Fertilizers, 82 cents; preparation of land, $2.11; seed, 24 cents; planting, 44 cents; cultivation, $2.24; gathering $2.20; miscellaneous, 47 cents; land rental or interest, $3.75. The relative importance of these items naturally varies somewhat in different sections of the United States, the fertilizer cost being high in the East and South and little or nothing in the Central and Western states, while other items show some differences.

More accurate and detailed studies show that on the average 16 to 20 hours of man labor and 40 to 50 hours of horse labor are required to grow and harvest an acre of corn in the Corn Belt, where it is husked from the standing stalks. In the eastern states, where the common practice is to cut the fodder and then husk from the shock, the usual

Table V. Average acre production, average acre cost, and average bushel cost for the Corn Belt and Eastern States respectively in 1921.

Section	Average acre production	Average acre cost	Average cost per bushel
	Bushels	*Dollars*	*Cents*
Corn Belt states	45	24.26	53
Eastern states	55	36.89	67

requirement was about 50 hours of man labor and 50 to 60 hours of horse labor. In addition, there is the cost of seed, fertilizer and manure, equipment, overhead, and the charge for use of land, either as rental or interest on the investment. The largest single charge is usually that for the use of the land. Corn-belt studies made in 1921 showed that the average cost of producing an acre of corn in various sections that year ranged from $20 to $27, with an average of $24.26, while in the eastern states the cost ranged from $30 to $40, with an average of $36.89. The average yield of corn that year on the farms studied in the Corn Belt was 45 bushels, and in the East, 55 bushels, giving costs per bushel of 53 and 67 cents, respectively.

116. Acre Value. The average annual value of an acre of corn in the United States for the five years from 1916 to 1920 was $29.60, but in 1921 it was only $12.54 and in 1922 it was $18.55. The highest value is shown in the North Atlantic states, the Far Western and the Middle Atlantic states ranking next in order. The average acre value in Illinois for the five years from 1918 to 1922 was $28.81 and in Iowa, $30 65. In 1922 the acre values in these two states were $21 30 and $25.20, respectively. The highest acre value in 1922 was in Rhode Island, $48.00; the lowest, in Florida, $9.80.

CORN IN CROP ROTATIONS

117. Corn Decreases Fertility. It is well known that if a piece of land that has been cropped to grain for a number of years is planted to corn and cultivated well, better crops of grain will be produced on the field the following year or years. This has led to the belief that corn is a soil-building crop. Tests conducted at many experiment stations where corn has been grown on the same plat continuously for a number of years without fertilizer show that the productivity of the plats has gradually decreased until very poor yields result. In fact, these experiments show that the productivity of the soil is more rapidly decreased by corn than by grain crops. These two facts seem somewhat contrary, but when studied prove to be just what might reasonably be expected.

118. Cultivation Liberates Plant Food. As stated elsewhere, plant food is made soluble or available for plants very largely by the decomposition of vegetable matter. Vegetable matter can decompose or rot only when in the presence of air and moisture. Hay in the mow does not rot, because it is kept dry. Silage in the silo does not rot, because air is kept away from it. Vegetable matter in the soil, that is, manure and roots and stems of plants, will naturally

decompose more rapidly if proper conditions of air and moisture are maintained than when they are not present.

The corn crop is commonly cultivated throughout the growing season. This cultivation aërates the soil and conserves moisture, hence decomposition takes place more rapidly in a cultivated field than in a field that is not culti-

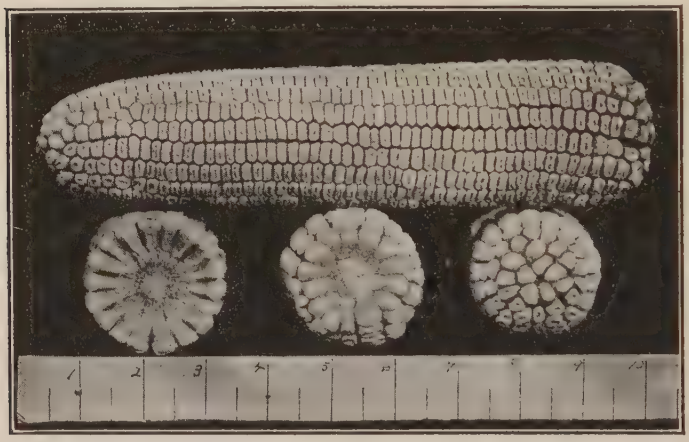

Figure 35.—Ear of Boone County White corn. A popular white dent variety in southern Indiana, Illinois, and Iowa and northern Missouri. Grown to some extent in the South.

vated. This rapid decomposition caused by cultivation liberates large quantities of plant food. On this account, planting a field to corn stimulates the liberation of plant food and naturally leaves the soil richer in available plant food for succeeding crops. This may easily account for the larger yields which usually follow cropping a field for one year to corn. It is evident, however, that if the field is planted to corn year after year, the supply of vegetable matter will be quite rapidly depleted, so that the soil will soon fail to respond to the stimulation of cultivation. Thus, when a field is planted for a number of years in succession, it rapidly decreases in productivity.

119. Importance of Corn in the Rotation. Owing to the stimulating and the cleaning effects of cultivation on the soil and the influence the crop has on the number of live stock kept, by furnishing an abundance of cheap and desirable feed, corn has a very important relation to the cropping system of the farm. Diversification, rotation of crops,

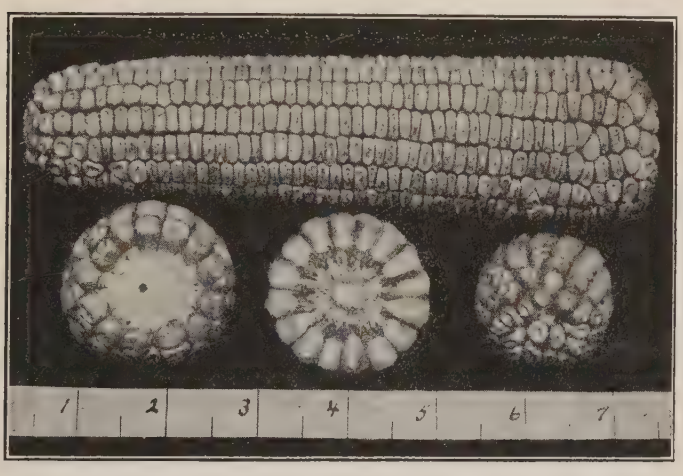

Figure 36.—Minnesota No. 13, a type of yellow dent corn adapted to the Northern states, improved by the Minnesota Agricultural Experiment Station.

and the keeping of live stock usually lead to increased production and larger farm profits.

120. Rotations Which Include Corn. One of the very common and desirable rotations for corn is the following: First year, grain; second year, clover; third year, corn. This rotation is giving good results, especially on some of the lighter soils. On heavier soils, there is danger, if the corn and clover are fed on the farm and the manure returned to the land, that the soil will become so rich that the grain crop following the corn will lodge. It is, however, an excellent system of rotation for building up run-down soils. When they are so built up that difficulty is experienced in the

lodging of grain crops, the rotation may be made longer by growing corn two years in succession. This plan makes the rotation a four-year one, as follows: First year, grain; second year, clover; third, and fourth years, corn. Owing to the strong feeding habits of the crop and to the rapid decomposition of vegetable matter which takes place in corn fields, two years of corn will usually reduce the available plant food in the soil sufficiently to permit the growth of the proper grain crop without danger from lodging.

Corn may be used in combinations in rotations, depending entirely upon the needs of the farm. A four-year rotation adapted to a farm on which it is desired to grow a comparatively large quantity of grain might be as follows: First year, grain; second year, clover; third year, corn; fourth year, grain. If desirable, another grain crop might be added, which would make a five-year rotation with one year of corn, one year of clover, and three years of grain. Unless considerable quantities of fertilizer were applied, such a rotation would by no means maintain the productivity of the soil. Another practical five-year rotation including corn is: First year, grain; second year, meadow; third year, pasture; fourth year, corn; fifth year, grain.

In the Southern states, corn ranks second only to cotton in importance. These two crops are almost always included in any rotation which is devised for this section. Cowpeas are quite generally grown to add nitrogen and are sometimes plowed under to increase the vegetable matter in the soil. They are often planted with the corn, either in rows or between them at the last cultivation. A very good rotation for the South is: First year, corn and cowpeas; second year, cotton followed by winter grain; third year, grain, followed by cowpeas for hay.

In Chapter XXVI the general subject of the rotation of crops is discussed in its broader aspects.

SELECTION OF SEED CORN

121. Importance of Good Seed. One of the important factors in the production of a good crop of corn is good seed; that is, seed of the desired type, carefully selected from corn adapted to the locality, and stored so that it will remain good. There is no doubt that it is possible, in nearly every community, to obtain greatly increased yields of corn simply by giving careful attention to the matter of the selection and the care of the seed. While good crops may be produced from only fairly good seed if soil and other conditions are favorable, it is the universal result that where carefully selected seed is used, increased yields are obtained. Weather conditions are often unfavorable at planting time, and only seed of strong vitality can be depended upon to withstand these unfavorable conditions and send forth good, strong plants. Time spent in selecting seed corn is, as a rule, the most profitable that is devoted to the corn crop.

122. Quantity of Seed to Select. From fifteen to twenty ears of corn are required to plant an acre. When selecting corn by the ordinary field method, it is not possible to make as careful a selection as is desired for the final seed for planting. On this account it is recommended that at least fifty ears of corn be selected for each acre of corn it is planned to grow the following year. This will leave margin enough for careful selection the following spring, and the seed thus discarded can often be sold to advantage or used as fodder corn seed.

123. Time to Select. The time of selection will naturally depend largely upon the locality. Corn gains nothing by being left in the field after it is mature and the sooner it is gathered and placed under cover to dry out, where it will not be affected by the weather, the better it will be for seed purposes. In the North, it is extremely important that corn be selected early enough in the fall to allow ample time for it

to become dry before freezing weather. For this reason it is very advisable, if one does not have suitable storage, to select corn just as soon as it is well ripened.

Another important factor in favor of early selection, especially in the North, is that one may choose the ears from plants that have a tendency to ripen early. Almost universally, some ears and plants mature from a few days to two or three weeks earlier than some of the other ears and plants. If the seed is selected from these plants, there is a tendency to fix the character of early maturity. If the corn is not selected until all the plants are mature or until they have all been killed by frost, it is not possible to tell the early maturing ears from those that matured later. If selection is deferred and the season happened to be favorable, so that the corn continued to grow for a week or more after the date of the first killing frost, ears might be selected that matured eight or ten days after that date. Corn planted from such seed the following year is likely to be killed by frost before the main part of the crop is matured.

Figure 37.—The kind of corn which should not be used for seed.

Another advantage of early selection, while the plants are all in their normal condition, is that it is possible at that time to give attention to the character of the plant on which the ear grew, which is an important factor in getting the

best possible seed corn. The stalk should be vigorous, of medium height, and not alone in the hill. The ear selected should be of medium size, mature, and hang tip downward from a medium height.

124. How to Select. In the North, it is important to select seed as soon as the crop is ripened and before it is practical to husk the crop. The following method of selection is commonly practiced: Go into the field from which the selection is to be made, with a common sack swung over one shoulder by means of a string so that the open end will be directly in front of the body and so that both hands will be free to use. Then, by walking between two rows, ears of desirable appearance can be examined and the good ones husked and put into the sack. Selection can be made quite rapidly in this way. It is desirable to have a wagon at the end of the field into which the sack may be emptied when it gets too heavy to carry comfortably. One man can easily select five hundred ears of corn in a day in this way and do reasonably careful work.

Allowing fifty ears of this field-selected seed to each acre which is to be planted the following spring, one would select enough in this manner in one day to plant ten acres. Allowing $3 a day for labor, the extra cost of seed corn saved in this manner will not exceed 30 cents an acre, which is certainly very reasonable for the better grade of seed obtained.

In the southern part of the corn belt, seed selection may be deferred until the main part of the crop is husked. The method usually followed in selecting seed at this time is to have a box fastened on the side of the wagon box into which the corn is husked, so that whenever a desirable ear is found it may be put into this small box and kept separate for seed.

125. The Type to Select. One of the laws of breeding which is recognized by everyone familiar with either plants or animals is that like produces like. If a person wishes to grow corn of any particular type or quality, he can expect

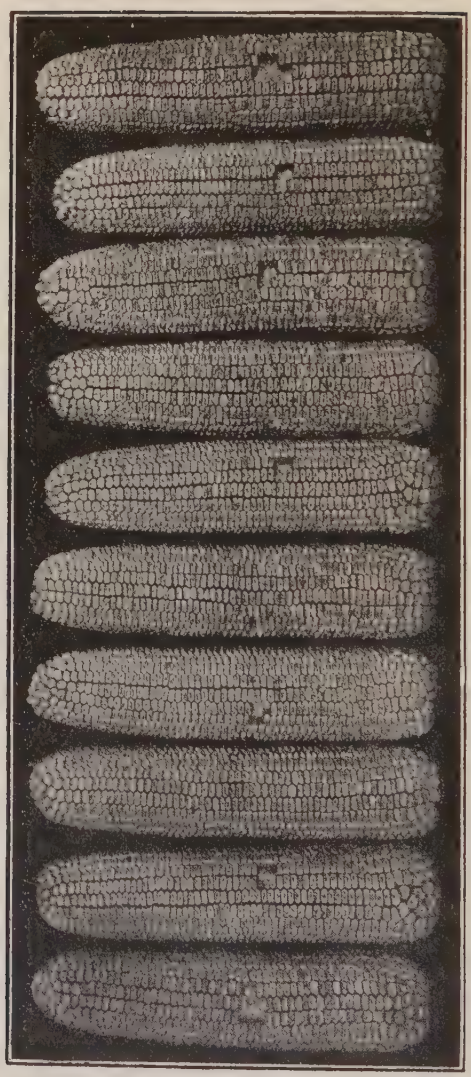

Figure 33.—The sweepstakes ten ears of corn at a National Corn Exposition. Note the uniformity of the ears and the manner in which they are filled at butt and tip.

to do this only by planting seed of that type and quality. Nearly everyone desires to grow corn that yields well and is of good quality. To accomplish this result it is necessary to select seed ears of the type known to give satisfactory yields of the quality desired.

If one has a variety of corn that is larger than it is deemed desirable to produce, the variety may be made smaller by selecting ears of the desired size. On the other hand, if it is thought advisable to increase the size of the corn, larger ears should be selected. Likewise, any character that is desired may be fixed by persistently selecting every year ears of corn having that character.

126. Fixing the Type in Mind. One needs but to examine an ordinary wagon load of corn as it is picked to be convinced that there are good and poor ears in every field. Also, there are usually a number of good ears of different types in every lot of corn; for instance, there may be good ears of corn having twenty rows of kernels and other good ears having only sixteen rows of kernels, all coming from the same field or variety. In selecting seed corn it is highly desirable that one have the desired type clearly in mind and select to that type persistently. It is a good plan to look over a large number of ears and pick out one that is as near the ideal as possible. This ear should be examined occasionally to keep clearly in mind the type sought.

The Extension Division of the Iowa State College has suggested four questions which should always be asked regarding each ear of corn selected. These questions are: (1) Will it yield? (2) Will it mature? (3) Does it show improvement? (4) Will it grow? These four simple, practical questions may easily be kept in mind and if all can be answered affirmatively as to each ear of corn selected, it is reasonably certain that the seed corn is good.

127. Yield and Maturity. Indications of yield are size of ear, depth of kernel, type of kernel, and proportion of corn

to cob. The importance of yield is understood by all. Indications of maturity are firmness of the ear of corn or firmness of the kernels on the cob, the ease with which the kernels may be shelled from the cob, and the firmness and character of the kernel. Indications of immaturity are discoloration, blistering, or imperfect development. The importance of maturity can hardly be overestimated. There is nothing quite so discouraging in corn-growing as a crop of

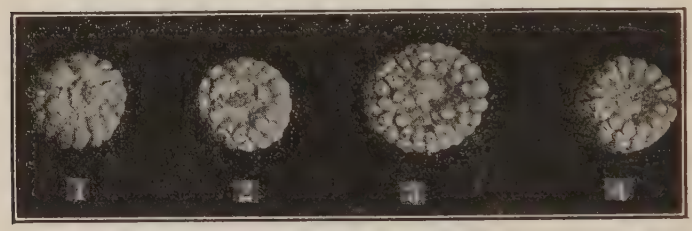

Figure 39.—Butts of ears.

soft corn. Corn that is well matured has a considerably higher feeding value than immature corn. Mature corn can be kept easily throughout the year and will germinate strong the following spring, while immature is very likely to be injured or greatly weakened for seed. The farmer who grows corn that is practically certain to mature may have slightly smaller yields in favorable years, but he usually more than makes these up by having a fair crop even in poor corn years, when many others have failures. In poor years for corn production, when the supply is short, the crop is worth more to the bushel than in good corn years, which fact more than compensates for the slightly smaller yields in specially favorable seasons.

128. Indications of improvement in corn are seen chiefly in the uniformity of the ears, just as pure-bred animals are much more uniform in type than scrubs. If a sample of corn is fairly uniform, it indicates that it has been bred along one line for at least several generations. By having its

characters firmly fixed, it is more likely to bring forth good corn than is a sample that lacks this quality.

129. Indications of strength of germination are maturity, large germs, and dry, sound, bright-looking kernels. Such indications are not always reliable guides and the only practical way of being sure that an ear or a sample of corn will germinate well is to test it. (Sections 74-77).

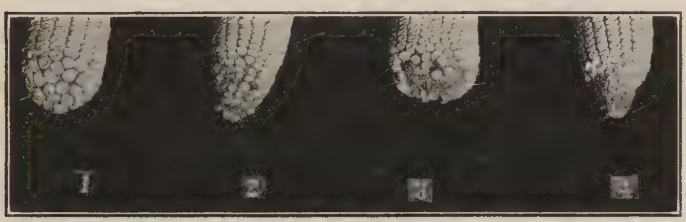

Figure 40.—Tips of ears: (1) A good tip, well-filled; (2) a long, tapering, irregular tip; (3) a broad tip, not filled out; (4) an unfilled tip. Only No. 1 is desirable.

130. The Value of Good Ears. The object of the corn grower is to produce one good ear of corn on each stalk and to have at least three strong stalks to each hill. On an acre of corn planted 3 feet 8 inches apart each way, there are 3,240 hills. If one good 10-ounce ear of corn in produced on each hill, a yield of 28.9 bushels will be obtained. This yield is 0.4 bushel to the acre more than the average yield of corn throughout the United States during the five years from 1918 to 1922. A perfect stand with a 10-ounce ear produced on each of three stalks in each hill would produce a yield of 86.7 bushels to the acre, which yield may be reasonably excepted on good corn land in the corn belt from good methods of culture.

131. The Form of Ear. The form of ear and type of kernel of course depend largely upon the variety of corn. In a general way, the ears that have proved capable of producing the best yields are somewhat uniform in circumference from butt to tip; that is, they do not taper noticeably. Ears

on which the rows of kernels are straight are to be preferred to ears with crooked, irregular rows, as a much larger proportion of the kernels is uniform and consequently suitable for seed. Ears of corn with coarse, rough butts are objectionable also. It is generally advisable to select ears whose tips are rather well filled. If the tips are not filled, the corn is immature or has not developed properly.

Figure 41.—Kernels showing large and small germs, taken from different ears of corn. The left-hand kernel in each pair shows low feeding value, while the right-hand kernel with large germs shows a high per cent of oil and protein. (Holden.)

132. Type of Kernel. In the careful selection of corn, the kernel can not be overlooked. Each kernel should be of such shape that the space about the cob is fully occupied. Each kernel should show a large, strong germ, because the germ is the plantlet that is to make the next generation of corn. The germ is also of importance because it contains a considerable portion of the feeding value of the kernel, hence kernels with large germs are worth more for feed than those with small ones. Kernels with sharp-pointed tips are sure to have small germs. Full development and bright lustre are essential.

It is desirable to obtain as large a proportion of shelled corn to cob as possible, and depth of kernel is a very fair indication of this proportion; but the fact that deep-kerneled varieties are almost always later in maturing than the types with more shallow kernels must not be overlooked. Care and judgment must always be used to select kernels as deep as is practical, and still get corn that will mature safely in the locality.

Figure 42.—The seed corn tree. Nails are driven in rows on the sides of the post and the seed ears are stuck on them.

STORING SEED CORN

133. Conditions for Storing. In storing seed corn, one must recognize the fact that in each kernel of corn there is a small, living plant, which under certain conditions may be injured. If corn is placed in a damp, warm atmosphere, the germ is likely to be injured by molding. If the corn is exposed to severe cold while it still contains a large percentage of moisture, the cells in the germ are very likely to be broken by the expansion of the moisture on freezing and the germ thus destroyed. It is thus apparent that the safe storage of seed corn requires that it should be dried out quickly, that it be kept in a place where it will remain dry, and that it be not allowed to freeze until it is thoroughly dry. Though corn will stand considerable freezing without injury when it is dry, it is better to protect it from frost if possible, for it is difficult to determine just when it is dry enough to be safe.

134. Storage Houses. Where large quantities of seed corn are handled, as is the case with seed firms, special seed-

houses well provided with ventilation are constructed. The corn is put into racks or very narrow cribs, which are often made of woven wire so that free circulation of air is possible. On the farm, where only enough seed corn is saved for home use, more careful methods can very profitably be followed.

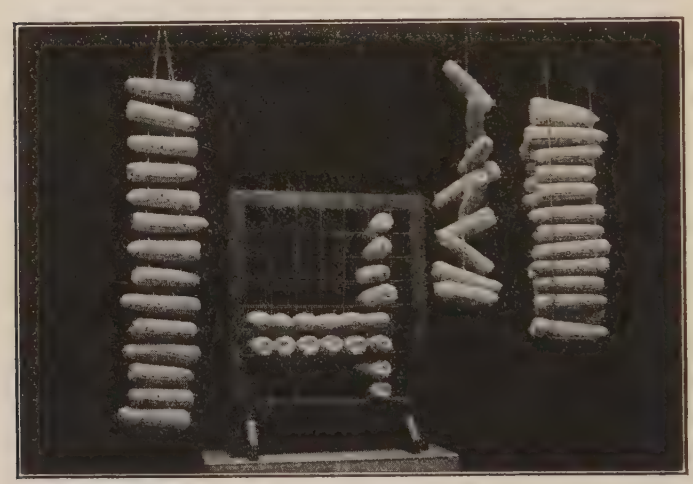

Figure 43.—Several methods of placing seed corn for storing; the double-string method at the left.

135. Storing on the Farm. The right method is to store the ears so that no two are touching and so that each ear is exposed to free circulation of air.

Any convenient place where corn can be dried out before cold weather, preferably without artificial heat, and where mice can be kept from it may be used with very satisfactory results. A well-ventilated attic with at least two windows that may be opened or closed at will and which gets some heat from the rooms below is an ideal place for storing seed corn. If the cellar is dry and well-ventilated, it affords a good place for storing seed corn; but, if it is not dry, corn should not be stored there. Cellars are not usually suitable

unless they are provided with furnace heat. Storing in granaries over bins of grain is not safe, as the grain is likely to heat or to give off moisture and injure the corn.

136. Methods of Storing. As previously stated (Section 134), seed corn in large quantities is usually stored in narrow bins through which air can circulate quite freely. Some practical methods of storing smaller quantities of corn on the farm are shown in Figures 42 and 43. The seed corn tree is a square, octagonal, or round post 4 to 6 feet high, fixed to stand erect on a broad base. Finishing nails are driven into it just far enough apart so that when ears are jabbed on them, butts first, they will just miss one another. This makes an excellent place to store seed corn. Another very convenient way of hanging up seed corn is the double string method. Other ways are illustrated in Figure 43.

USES OF CORN

137. Importance as Food. The place corn has attained as most important of all American farm crops is due to the quality and variety of food products it furnishes and to the fact that no other cereal crop can compete with it successfully in the quantity of food it will produce to the acre or to the unit of labor expended.

Corn is used for a great variety of purposes, both in its natural state and in the form of manufactured products. Its greatest and most common use is in the form of feed for live stock. It is used for this purpose as grain, as roughage in the forms of fodder corn, silage, and stover, as green feed, and as a pasture crop.

By far the most important part of the corn plant is the grain. Its value in the United States is usually greater than the value of any other two farm crops and greater than the wheat, oat, barley, flax, rye, and tobacco crops combined. As a feed for live stock, a pound of cornmeal is worth more than a pound of oats, barley, or bran.

About three fourths of the total net nutrients of the stalk and ears is contained in the grain. The whole kernel contains 11.33 per cent of crude protein, 82.26 per cent of carbohydrates, 4.86 per cent of fat, and 1.54 per cent of ash.

138. Use as Human Food. As food for man, corn is most largely used in the form of cornmeal, from which numerous dishes are prepared. It is also used as hominy, corn flour, cerealine, green corn, canned corn, pop corn, starch, sirup, corn flakes, and corn oil. The refined oil is used for shortening, and sometimes as a substitute for olive oil.

139. Manufactured Products. One product of the corn crop is canned green sweet corn, which represents an industry of considerable importance. Starch is a valuable product manufactured from the grain of corn which is used both as food and for starching, or stiffening, fabrics. It is likewise converted into a form of sirup known as corn sirup. Cornmeal is the finely ground corn, largely used as food. Corn flour is even more finely ground; it is used as a partial substitute for wheat flour in bread making. In the manufacture of starch, flour, and cornmeal, the germs of corn are removed. These germs are heated and pressed and a valuable oil is extracted from them. This oil in the crude form is used in painting and as a lubricant, and is vulcanized into a cheap grade of rubber. It may also be refined and used as a food product. Corn flakes and some other very palatable breakfast cereals also are manufactured from corn. Alcohol and distilled liquors are manufactured largely from this grain. The pith of cornstalks is used in the manufacture of explosives and as a packing material for battle ships. The cobs are made into pipes, and the stalks are now being used to some extent in the manufacture of paper. Corn husks are used for making mattresses and for packing.

140. By-products. The by-products from corn canning factories, the husks and cobs, are often used in the form of

silage or as green feed. Corn cake, a by-product left from the manufacture of corn oil from the germs of corn, is also valuable stock feed. Gluten meal, a by-product from starch factories, is richer in protein and considerably richer in carbohydrates than linseed meal. It is highly prized as stock feed. Corn bran, another by-product in the manufacture of cornmeal, cornstarch, and breakfast foods, is valuable feed for stock, though it is not as valuable pound for pound as common wheat bran. It is quite commonly mixed with gluten meal, and the mixture is then sold as gluten feed. Distillery slops, a watery by-product in the manufacture of alcohol, is of considerable importance as stock feed, though naturally it must be fed locally as it is too bulky to ship far. Malt left from distilleries is dried and sold as distillers' grains, a valuable live stock feed.

DISEASES OF CORN

141. Smut. Corn smut is well known to every one familiar with corn. In some years, when conditions are favorable, considerable damage is done by it. It appears as black, slimy masses, which may be on the stalks, leaves, tassels, or ears. Corn smut is a parasitic plant which lives on the juices of the corn plant, and in this way reduces the total valuable product of the crop. The smut masses which appear on the surface are made up of myriads of spores by which the disease is reproduced. These spores are capable of living over winter in the soil or in manure piles. They may even multiply in the manure under favorable conditions and then be spread on the soil with it. When they start to grow in the spring, the smut plants they produce attack the young corn plants, sending their mycelia into the tissues. Smut may attack corn at any time during the growing season, usually most abundantly when the plants are growing rapidly and are consequently tender, usually when they are a foot or more high.

As the spores are not usually carried on the seed, there is no use to treat it for smut. Remove and burn the smutted parts of the plants. Do not feed these to stock, as they will only return through manure to the field. Rotation of crops and the manuring of grass land a year previous to planting it to corn tend to reduce smut.

Experiments have shown that "cornstalk disease" is not caused by eating smut. Several pounds a day have been fed to cattle without detrimental results.

142. Corn Root Rots. Several rots affect the corn plant, from the germinating seedling to the mature ear. When on seedlings, they may lessen vigor and reduce stand. At later stages, they may cause the roots to rot, so that the plants blow over; or the stalks, ear shanks, and ears may rot. The ears may wither and apparently mature early. These ears must be avoided in seed selection. To avoid injury from corn rots, select seed ears free from disease, and rotate crops.

One of the corn rots and wheat scab are produced by the same fungus. Neither corn nor wheat, therefore, should follow each other where wheat scab is a serious pest, unless all crop refuse is destroyed immediately after harvest.

143. Bacterial Diseases. Corn is subject to several bacterial diseases, but the damage done by them is not serious and they need not be discussed.

INSECTS AFFECTING CORN

144. Wireworms. Wireworms, which are the larvae of the click beetle, sometimes do serious damage to corn for a year or so following the breaking up of sod land. The beetles deposit their eggs in sod land, and the following spring the eggs hatch in the form of small, reddish-brown, shiny worms. These worms live in the soil for a couple of years before they change into the beetle form. On this account they give trouble longer than do cutworms. The most effective manner of combating these worms is fall plowing,

which disturbs the eggs and consequently causes many of them to be destroyed by the severity of freezing.

145. Cutworms. Cutworms are one of the most common enemies of the corn crop. Like wireworms, they are common only in or near sod land. They are usually grayish-brown in color, and are from 1 to 1⅞ inches long. They attack the corn plants at night and cut them off just at the surface of the ground. Fields of corn are often completely destroyed by them. Fall plowing, as suggested for wireworms, is somewhat effective with cutworms, though they are not entirely controlled by this treatment. Thorough cultivation until corn planting time is also effective, as many of the worms are injured by the cultivation, and if nothing is allowed to grow they have difficulty in getting food. The most efficient method of control is rotation of crops, with fields left in grass not more than two years in succession. Poison is sometimes used, though it is much more effective and practical in the garden than in the field. A mixture of 1 pound of Paris green and 30 pounds of bran, scattered in little piles near the hills of corn, will destroy many of the worms. A little sirup or sugar added to this mixture makes it more effective.

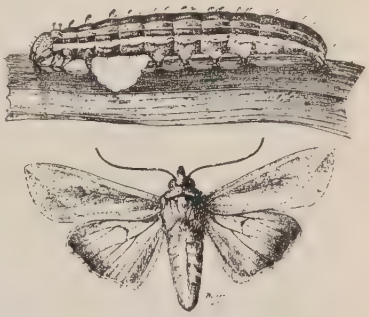

Figure 44.—Army worm and adult moth.

146. Army Worm. The army worm is a name given to certain types of cutworms when they appear in large numbers and move from field to field. They usually attack plants later in the season than the common cutworms, and eat the upper parts of the plants rather than those just at the surface of the ground. The most effective treatment

for these worms is fall plowing and rotation of crops, as suggested for the common cutworm.

147. White Grubs. The white grub, very commonly seen when plowing land, especially in the spring, is likewise a serious pest to the corn plant. These grubs, like wireworms, live in the worm stage for two years, and consequently trouble from them may appear in two succeeding crops on the same field. They attack the roots of the corn

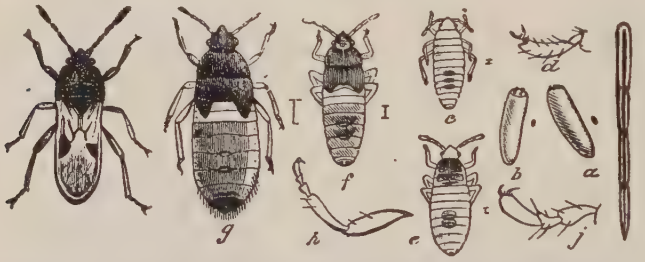

Figure 45.—Chinch bug, adult at left, a, b, eggs; c, newly hatched larva; d, its tarsus; e, larva after first molt; f, same after second molt: g, pupa; h, enlarged leg of adult; j, tarsus of the same enlarged; i, proboscis, enlarged. (*Riley*)

and very seriously check its growth. The same treatment as for wireworms is effective.

148. Chinch Bugs. The chinch bug, which is common only periodically, is known best in grain fields, where its injury is greatest. Often entire fields are cut down by these insects. They live over winter in the adult stage, usually under rubbish of some kind. The female emerges in the spring and lays the eggs, and in a short time the young are hatched. The egg-laying period extends over several weeks, so the young are usually seen in all stages of growth. They attack plants anywhere above the ground, sucking the juices from them. As they usually appear in large numbers, their damage is very serious. Their attacks are usually after the grain fields on which they have been living are harvested.

Clean farming is an effective remedy, because it reduces the number of suitable places in which the insects may live

over winter. When it is feared that they are to attack a cornfield, a strip a rod or so wide, plowed and pulverized to fine dust, is effective in checking their progress. Furrows are often plowed about a field and a log dragged along the furrow to make a fine dust in it. The little insects, owing to the moving of the dust, have difficulty in crossing the furrow. Holes bored with a post auger at intervals along the furrow serve as efficient traps to catch large numbers of the insects. They may be killed in these holes by burying them or by pouring a small quantity of kerosene on them. Strips of tar are also effective in checking their progress.

149. Grasshoppers, sometimes do serious injury to corn. Like chinch bugs, they attack the corn, as a rule, only after the other crops have been destroyed or harvested. The edges of the fields next to grass land or grain fields are usually attacked first. Fall plowing is one of the most effective methods of preventing the ravages of grasshoppers. They may be killed in large numbers by spraying a strip along the cornfield with arsenate of lead, mixed in the proportion of 5 pounds to 100 gallons of water. The cornstalks thus sprayed cannot be used safely as feed for stock.

150. Grain Weevils. Corn kept in storage is sometimes attacked by grain weevils. These insects eat into the heart of the kernel and destroy the germ. In seed corn they are most effectively controlled by putting the corn in a tight box, can, or bin, and setting a shallow open dish of carbon bisulphide on top of the corn. This can be obtained at any drug store. It evaporates quickly and the gas, being heavier than air, settles down among the grains of corn and kills the insects in it. Care must be taken not to breathe the fumes of this gas. Large quantities of corn may be treated in the same way if tight rooms can be provided.

151. Crows and gophers often attack corn after it is planted, digging up the kernels or young plants and de-

stroying them. The work of these birds and rodents may be checked to a considerable extent by treating the seed corn with tar. The corn is put in a kettle slightly warmed and moistened; then tar is applied and the corn stirred, just enough being used to make a very thin film of tar about each kernel. A tablespoonful should be sufficient to treat 6 or 8 quarts of seed corn. After the kernels are coated with tar, planting is facilitated by applying road dust, ashes, or air-slaked lime, so that the kernels will not stick together.

IMPROVEMENT OF CORN

152. Problems in Improvement. There are many problems connected with the improvement of seed corn which are not met in the improvement of some of the other farm crops. The chief difficulty involved in improving corn comes from the fact that it is open-fertilized; that is, the female flowers of one plant are naturally fertilized by pollen from the male flowers of other plants. On this account selected strains are very likely to become mixed with poorer individuals, and the work of selection may in this way be entirely lost or its effect greatly reduced. While progress is made by the selection of the best ears of corn, the ear indicates only the character of the mother plant on which it grew and nothing of the character of the male plant or plants that produced the pollen to fertilize its kernels. Both parent plants must be taken into consideration.

153. The Ear-to-Row Method. The fact that appearance does not always enable one to select the ears that will give the largest yields has long been recognized. Many years ago corn breeders adopted the practice of planting the seed from the selected ears in separate rows side by side in a uniform field, so that their comparative yielding power could be determined. Such ear-to-row tests almost always indicate a very wide variation in the yielding power, even though such ears may be similar in appearance. It is not at all

uncommon to find ears of the same variety and selected to the same type which yield 100 per cent more than other ears which, so far as one can tell, appear to be equally good.

For ear-to-row tests, a uniform field wide enough to plant as many rows as there are ears to be tested should be pro-

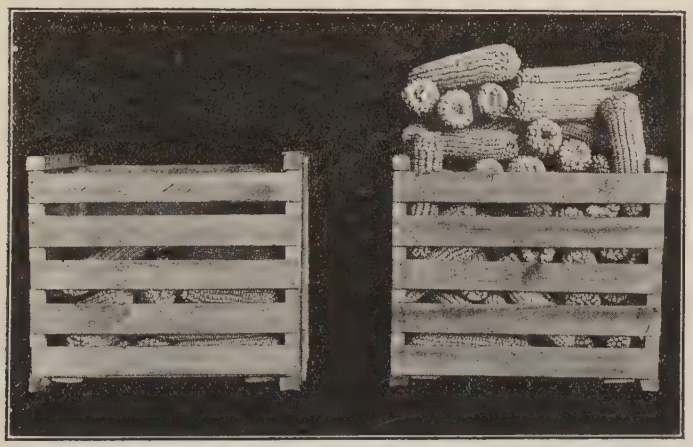

Figure 46.—The value of the ear-to-row test. The crates show the yield from two rows which appeared to be equally good.

vided. The rows may be as long as desired; they are limited, of course, by the number of kernels on the ears to be tested. A fair-sized ear will plant a row from 40 to 50 rods long. Many corn breeders use shorter rows and plant duplicate rows from each ear, to serve as an additional check in determining the best. At harvest time, the product of each ear is carefully weighed and the high-yielding and low-yielding ears thus discovered. The corn from the low-yielding rows is discarded, and only seed from the high-yielding rows is saved for future planting.

The chief objection to this method is that the high-yielding rows of corn have been fertilized in part with pollen from other rows. The individual kernels on the selected

ears, while they are known to come from a mother plant of high yielding power, are from an unknown male parent, and many kernels in ears selected from the highest-yielding row have been fertilized by pollen from low-yielding rows.

154. Pedigreed Varieties. In order that a plant or an animal may be pedigreed, its ancestors on both sides must be known. For a pedigree to be of material value, the performance records of its parents must likewise be known. It is quite evident that it would be impossible to produce a pedigreed variety of corn by the ear-to-row method of breeding outlined in the preceding paragraphs. While the mother plant and the record of the mother plant for generations might be known, the male plant is absolutely unknown.

Pedigreed corn may be produced by starting with the ear-to-row test, selecting 50 to 100 ears as desired. The corresponding number of rows is planted from these ears, but half or less than half of the seed from each ear is used; the other half is reserved for future use. The parts of the ears retained are numbered to correspond with the ears planted. The test is conducted in the same manner as the ear-to-row test.

The advantage of this method is that after the ear-to-row test has shown which are the high-yielding ears, the best two may be mated by planting the remaining portions of them the following year and a cross between two ears of known high-yielding power thus obtained. For example: If ear No. 25 yields 80 bushels to the acre and ear No. 42 yields 85 bushels, while the rest of the ears in the test yield 70 bushels or less, it is plain that ears 25 and 42 are the highest yielding ears of the lot. The second year, the remaining portions of these two ears are planted in an isolated seed plat, alternate rows being planted with seed from the two ears. When the corn in this plat begins to tassel, all plants in rows from one of the ears are detasseled and

the other plants left to produce tassels. It is then certain that all the ears on the detasseled rows are fertilized with pollen coming from plants produced from the other ear. The seed saved from the detasseled rows may really be called pedigreed corn; that is, the male parent and its performance record, as well as the mother plant and its record, are definitely known.

In such a breeding plat, it is necessary to take every precaution to prevent the introduction of pollen from any other corn. All the corn produced on the row not detasseled would, of course, be inbred; that is, these ears would naturally be fertilized by pollen produced on plants from the same ear. All this corn would be discarded and seed saved only from the detasseled rows.

155. Inbreeding. One of the difficulties encountered in this plan is the inbreeding which is likely to be brought about by this close selection of corn. This may be overcome by continuing the ear-to-row tests year after year. This plan calls for four separate plats or fields of corn each year. The first plat is devoted to the ear-to-row test. The second plat where the best ears, as shown by the ear-to-row test of the previous year, are mated, is called the breeding plat. The third is termed the multiplication plat, which may be of any size desired. Here the seed produced from the breeding plat of the year before is planted to obtain enough seed for field use. The fourth plat is the regular field of corn, the seed for which comes from the multiplication plat.

For the ear-to-row test which is conducted each year, some of the best ears are taken from the general field, some from the multiplication plat, and some from the breeding plat. When it is thought that new blood must be brought in from outside, selected ears of the variety with which one is working may be obtained from other farms or other breeders. By running all these ears together in the ear-to-row test and then selecting and mating together the high-

yielding ears each year, new blood can constantly be brought in from ears of known yielding power. This plan will quite probably be adopted eventually by all corn breeders.

156. The Need for Special Breeders. Too much time and too much careful work are involved in the scientific breeding of corn to make it practical for each farmer to attempt the work. Probably the average farmer will not care to go further in breeding work than to have a special seed corn plat, and not attempt to produce pedigreed seed corn, or even to conduct an ear-to-row test. Then, in every corn-growing community there will be room for a corn breeder. When this breeder has demonstrated that he has corn of superior quality especially adapted to the locality, he will have little difficulty in selling it at a price which will make it profitable for him to breed corn as a business. If he produces corn of high quality, it will be profitable for farmers in the community to buy seed of him.

157. The Farmer's Seed Corn Plat. Every corn grower can well afford to give some time and thought to the care and handling of a seed corn plat. The size of this plat will depend upon the acreage of corn grown. The object should be to have the plat large enough to produce sufficient seed of excellent quality to meet his requirements. If the seed corn plat is to be one acre in size, the proper method is to select the necessary number of ears, which is about twenty, to plant this plat, using extra care to select absolutely the best ears that can be obtained. After the ears are selected and tested, the plat is planted in the same way as the ordinary field; in fact, it is preferably a part of the regular corn field. If possible, it should be on either the south or the west side of the field, or on the side toward the prevailing winds, so that the pollen from the main portion will be less likely to fertilize the stalks in this seed plat. Care must be taken, however, that the plat is not near a neighbor's corn field, because the neighbor may not have as carefully selected corn

as that grown on the plat. It is better to have the seed corn plat near the middle of the main field than to have it near a neighbor's corn of a different variety or of inferior quality. A seed corn plat planted in this way may be cultivated with the rest of the field, so that very little extra work is entailed.

The best seed is planted on this plat and extra care is taken while it is growing that all weak and barren stalks are removed or detasseled, so that all ears produced on it will be fertilized from strong stalks that bear ears of corn. When the time comes to select seed, all the best corn produced in the seed plat is selected. The following spring the twenty best ears are selected and planted in another seed corn plat and the balance is used for the seed of the main crop. On a small plat of this kind, one can afford to use more care in selecting seed and in weeding out or detasseling the weak stalks than is practical on the large fields.

JUDGING CORN

158. Object of Judging. The judging of corn is not nearly so difficult as it at first seems. When one first looks at an exhibit of corn containing a large number of samples, it appears to be almost an impossible task to pick out the best lots. The chief object in the improvement of corn is to get a variety that will yield the largest possible quantity of food products to the acre. The work of the judge is simply to pick out the sample that, in his judgement, will produce the best crop of corn if planted the following season.

159. The Use of the Score Card. To become familiar with the important points in an ear or other sample of corn one should make a careful study of a score card. There are many different score cards in use. Nearly every state agricultural college has a score card for corn, each differing from those used by the other colleges. The difference is due to the fact that some points seem to be of more value in some sections of the country than in others.

SCORE CARD FOR CORN

(From Indiana Circular 18.)

Salient Points	Standard Score
Uniformity of Exhibit	10
Shape of Ears	10
Length of Ears	10
Color of Grain and Cob	10
Tips of Ears	5
Butts of Ears	5
Kernel:	
a Shape	10
b Indentation	5
c Uniformity	10
Seed Condition	15
Proportion of Grain to Cob	10
Total	100

SPECIAL TYPE OF SCORE CARD FOR CORN

USED BY THE EXTENSION DIVISION, IOWA STATE COLLEGE

		Points
I.	Will It Yield? That is, will it yield well; has it constitution; can we depend on it even when conditions are unfavorable?	25
II.	Will It Ripen? That is, will it mature; will it ripen every year; is it safe for the locality?	25
III.	Does It Show Improvement? That is, has it breeding; has it a distinct type; will it reproduce itself; has it several years of careful selection and improvement back of it?	25
IV.	Will It Grow? That is, has it vitality; will it germinate; will it all grow and grow uniformly, giving strong, vigorous plants?	25
		100

The object of the score card is simply to call the judge's or the student's attention to the various points of importance in the sample under consideration so that no point will be overlooked. The relative values given these different points are not so important as the fact that thay all are considered and that all the corn in each class is judged on the same basis. There are very few judges of experience who use the score card. They have trained themselves until they are able to observe and weigh the relative merits of the different points of each sample of corn presented to them.

160. Placing Samples. When attempting to judge a large number of samples of corn on exhibition, the first step

is to eliminate all the poorer samples from the class which is under consideration. As a rule, a large number of samples are easily ruled out, for there may be mixed kernels, soft ears, poor ears, or other disqualifying factors which are easily noticed. The second step is to get the remaining good samples together, where they may be easily compared. The third step is to place at one end of the exhibit table or bench the sample that seems best; then place the other samples as their merit seems to warrant. When one feels that they are placed in the proper order, or nearly so, a few kernels should be removed from each ear in each sample and placed at the end of the ear from which they were taken. It is easy then to compare the kernels to see whether or not they are good in shape, true to type, and uniform. Comparison of kernels is always necessary when the competition is close.

LABORATORY AND FIELD EXERCISES

1. Select from a large number of ears in the field, in the crib, or in the seed-house, 10 ears of corn as nearly alike as possible in the following respects: Cobs the same length, size, color and shape; tips and butts well filled; rows of kernels straight; the same number of rows on each cob; kernels of the same depth, shape and color, with uniformly large germs, and broad, well-filled tips. Note the large number of ears necessary to obtain the ten-ear sample, also the great tendency to vary.

2. Test 100 ears for germination by the individual ear method as described in this chapter. Make a note of the materials and time used to make the tester, put the 100 ears to test, and read the results. How much more corn must one obtain at 60 cents per bushel to pay for the time and materials used in making the test? Do you think it pays to test corn? How many acres will 100 ears of corn plant in check rows 3 feet 8 inches apart each way, and 3 kernels dropped per hill?

3. Make a seed-corn tree as described in this chapter. Note cost of materials and time required. How much did it cost you? How many ears of corn will a tree 6 feet high and with 8 rows of nails hold? How many such seed-corn trees would you need to store enough seed corn for your own use? Hang up some seed corn by the double string.

4. When the corn is ripe in your neighborhood, go into a field, select an average row, and count the number of stalks in 100 hills that have produced ears. (Count as hills each place where there should

have been a hill, whether any stalks are there or not.) Husk the corn and weigh it. Secure also the yield from the best hill and from the poorest. At what rate does the corn yield to the acre? How much would it have yielded had there been a perfect stand of 3 bearing stalks per hill? How much corn would have been produced to the acre had there been a perfect stand and every hill yielded as much as the best hill?

5. Secure two samples of corn, one graded, the other, ungraded, and a horse corn-planter. Block up the planter until the wheels turn free. Put in some of the ungraded seed, and run the planter until 100 hills have been dropped. Count the kernels dropped for each hill, and find the number of hills in 100 for which just three kernels were dropped. This will give the percentage of a perfect drop. Repeat the process, using the graded seed and changing the plates until the most perfect drop possible is secured. It may be necessary to file the holes in the planter plates to the right size, but it is better to secure new plates.

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553. Pop Corn for the Home.
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559. Use of Corn, Kaffir, and Cowpeas in the Home.
565. Cornmeal as a Food and Ways of Using It.
578. The Handling and Feeding of Silage.
773. Corn Growing for Droughty Conditions.
948. The Ragdoll Seed Tester.
1149. Corn Growing in the Southeastern States.
1175. Better Seed Corn.
1176. Control of the Root, Stalk and Ear Rots Diseases of Corn.

CHAPTER IV

WHEAT

DESCRIPTION AND CLASSIFICATION

161. Origin and History. As far back as history goes, wheat has been cultivated throughout the civilized world. On account of its antiquity, it is somewhat difficult to trace its origin. It is known to have been grown extensively in western Asia, in Europe, and in the northern part of Africa, ever since there have been any records of human events, and there are evidences which indicate that it was grown in China at least 3000 B. C. Wheat is mentioned in the first book of the Bible, and its use for bread-making dates back many centuries.

Wheat belongs to the grass family *Gramineae* and to the tribe *Hordeae*; it is very closely related to barley and rye. Some botanists think that it evolved, through a natural process, from the wild grass known as *Aegilops*, common in southern Europe. There is apparently no definite means of proving this theory, and whether it was developed in several countries independently or in one section and carried by the earlier tribes to other sections is also unknown. The important fact is that we have this valuable plant, adapted to a very wide range of soils and climatic conditions, giving us a product from which the standard bread of the world is made.

162. Botanical Characters. The wheat plant is a true annual, though in some sections it has been changed into what is known as a winter annual, being sown in the fall and maturing early the following summer. The numerous fibrous roots grow in whorls from the lower joints of the stem.

Most of the roots of the wheat plant are usually found in the surface soil, though under favorable conditions they have been known to grow to a depth of 7 feet.

Like most of the grasses, the stems of wheat are jointed and hollow, except in the variety known as emmer, in which the stems are more or less pithy. During the early stages of growth, the stems are very short, though they very early develop the entire number of nodes and internodes. For several weeks the plants devote their energies to producing roots and leaves and in developing new stems, or stools. When a good growth of leaves and roots has been developed, the stems shoot up quickly, simply by lengthening the internodes. Stooling is accomplished by buds which develop at the lower nodes into culms. In this way a large number of stems may be produced from one seed, the number being determined by the soil and climatic conditions and the thickness of planting. The stems vary in height from 20 to 50 inches, and in diameter from $\frac{1}{16}$ to $\frac{1}{8}$ inch.

163. The Leaves. As soon as a kernel of wheat germinates, it sends out leaves and roots to enable the plant to live after the supply of food in the seed is exhausted. These first leaves come from the lower joints of the stem, and perform their work during the early growth of the plant. As the stem grows, the leaves on the upper nodes develop and shade the lower leaves so that they wither and disappear. The leaves of wheat are alternate, one leaf appearing from each joint. The lower part of the leaf, the sheath, clasps the stem nearly the entire length of the internode. The sheath is split open on the side opposite the leaf blade, and at the junction of the sheath and blade is a ligule which clasps the stem lightly. The blades are long and tapering; they vary from $\frac{1}{4}$ to $\frac{5}{8}$ inch in width, and from 8 to 15 inches in length.

164. The Flowers. The flowers of wheat are arranged in a compact terminal spike. The spike is made up of a num-

ber of small spikelets, with two or more flowers in each spikelet. These spikelets are arranged alternately on the spike on either side of a central stem, or rachis. Each individual flower, or floret, is composed of a branched stigma, three anthers, and one outer and one inner flowering glume, commonly called the chaff. At the base of each spikelet are two flowerless, or empty glumes. At the base of and between the two flowering glumes is a small organ called the lodicule, which, when the stigma is ready to be fertilized, absorbs water, swells, and forces open the glumes. Figure 47 shows a spikelet and a flower of the wheat plant. The color of the glumes varies from light yellow to brown.

Figure 47.—At the left, a wheat flower; at the right, a spikelet of wheat in bloom.

Wheat is almost always close-fertilized; that is, each ovary is fertilized by the pollen from the same flower. The anthers are so arranged that the pollen is deposited on the receptive stigma as the anthers are being pushed up out of the glumes by the lengthening of the filaments. Cross-fertilization takes place most frequently in dry climates and on dry, warm days. Wheat varieties are very stable in character, for it is much easier to keep close-fertilized plants pure than open-fertilized ones like corn and rye.

The fruit, known as the kernel, at maturity is in the form of an oblong berry with a longitudinal crease, or furrow, in one side. The kernels naturally vary in size, color, weight,

Figure 48.—Types of wheat. From left to right, durum, bluestem, and fife.

and composition with the different varieties of wheat and with climatic and soil conditions.

165. Season of Growth. Wheat is grown successfully on some of the higher altitudes at the equator, and from there all the way to within 200 miles of the Arctic Circle. It does best in a temperate climate where the rainfall is not less than 20 inches, largely distributed through the growing season, and where the seasons are sufficiently long to allow 100 to 125 days of good growing weather free from frost. Spring wheat matures in from 100 to 125 days from the time of planting; winter wheat, in about 100 days from the beginning of the growing weather in the spring.

166. Classification and Varieties. Wheat may be classified in many different ways; as winter and spring wheat, as hard and soft wheat, as bread and durum, or macaroni, wheat, or by the botanical differences in the varieties. Wheat is commonly divided into eight classes or types; but as only four of these classes are of importance in the United States, only these four will be discussed.

In the first class, *Triticum sativum vulgare*, is found all the common bread wheats, including the hard and soft winter and the hard spring types. This is by far the most important class. The second class is the durum wheats, *Triticum sativum durum*. It is distinguished by resistance to drought and hardness of the grain. There are many varieties of this type, though few are specially adapted to this country. The third class is known as club wheat, *Triticum sativum compactum*. The wheats of this type have short, compact heads and produce very soft grain. They are commonly grown in the Pacific states. The fourth class of wheat, *Triticum sativum dicoccum*, is known as emmer, and is grown only to a limited extent in this country. It is often erroneously called spelt. This differs from common wheat in that the hull remains with the kernel when it is threshed and the stems are pithy instead of hollow. When growing, it is very

Figure 49.—Kernels of three types of wheat. Two upper rows, hard red spring (Preston); two middle rows, durum (Kubanka); two lower rows, hard red winter (Turkey).

similar in appearance to common wheat. From an economic standpoint, emmer is best compared with barley or oats, as it is grown in this country only for feed. It is better adapted to dry-land conditions than common wheat, and is of some importance where the rainfall is limited.

Varieties of common wheat are numerous, but varietal names, as in other common crops, are very misleading on account of the natural variation due to wide distribution.

167. Winter Wheat. From 60 to 70 per cent of the wheat grown in the United States is winter wheat; a large proportion of this is of the Turkey variety, which is the standard hard winter wheat. Kanred, a variety produced by selection at the Kansas Agricultural Experiment Station, is also widely grown. Fultz, Fulcaster, and Purplestraw are important varieties of soft winter wheats. The hard winter wheats are grown largely in Kansas and Nebraska; the soft winter varieties are produced in the states east of the Mississippi River. The leading states in the production of winter wheat are Kansas, Nebraska, Illinois, Indiana, Ohio, Missouri, Pennsylvania, Oklahoma, and Texas; in these states over 60 per cent of the winter wheat crop of the United States is produced. The principal limitation to the more extensive production of winter wheat is winterkilling.

168. Spring Wheat. Minnesota and North and South Dakota produce about 70 per cent of the spring wheat of the United States, a very large proportion of which is Marquis, a variety of the fife type. Until quite recent years, the most common varieties of hard spring wheat were Red Fife and Bluestem, but these have now been almost entirely replaced by Marquis. Preston and other bearded spring wheats known on the market by the trade name of "Velvet Chaff" probably rank second to Marquis in acreage at the present time. In the Pacific states, white spring wheats such as Pacific Bluestem, Baart, Federation, and Hard Federation, are grown.

169. Durum Wheat. Durum wheat is now largely grown in the spring wheat belt, more than a third of the wheat grown in Minnesota, the Dakotas, and Montana being of this class. It is mostly used for the manufacture of semolina for making macaroni, spaghetti, and similar edible pastes or is exported, although some is mixed with other wheats and ground into flour. The area of greatest production is in the Red River Valley of North Dakota and the section immediately adjoining it on the west, where it has largely replaced hard red spring wheat on account of its greater rust resistance.

IMPORTANCE OF THE CROP

170. World Production. The countries leading in wheat production in 1914, the last year for which accurate statistics are available, with the acreage and production of each according to the Bureau of Crop Estimates of the United States Department of Agriculture, are shown in Table VI.

Table VI. Leading countries in the production of wheat, with the acreage and production of each in 1914.

Country	Acreage	Bushels
United States	53,541,000	891,017,000
European Russia	62,316,000	597,000,000
France	16,049,000	319,677,000
British India	27,697,000	314,608,000
Austria-Hungary	12,664,000	190,655,000
Italy	11,783,000	169,442,000
Canada	10,293,000	161,280,000
Argentina	16,242,000	113,904,000
Australia	9,453,000	112,159,000

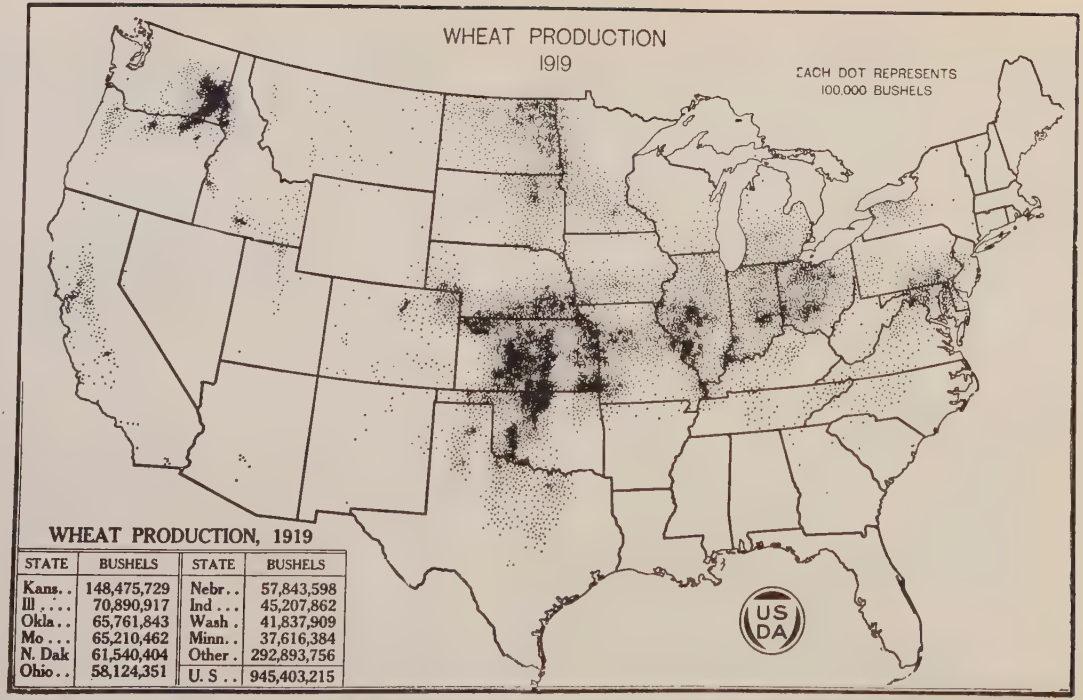
These figures are the latest available, as crop production was greatly disturbed by the World War and has not yet returned to normal in some countries. The total world production of wheat is normally about 3,600,000,000 bushels, or about the same as that of oats and corn. Owing to the higher weight per bushel, more pounds of wheat are produced than of either corn or oats, while the total cash value of the crop is greater than that of corn and oats combined.

In the three years from 1919 to 1921 the average annual production of wheat in the United States was 765,400,000 bushels. During the same years, British India averaged annually 302,947,000 bushels; Canada, 252,435,000 bushels; France, 249,000,000 bushels; Argentina, 185,000,000 bushels; and Italy, 166,000,000 bushels.

171. Production in the United States. In the United States, wheat ranks third in the number of bushels produced, the yield of both corn and oats being much larger, but in the weight of the crop wheat ranks second to corn. Wheat is likewise second to corn in total value among the cereals, but hay and cotton often outrank wheat in this respect. During the five years from 1918 to 1922, 64,189,000 acres on the average have been devoted to wheat, with an average annual production of 878,712,000 bushels, valued at $1,355,624,000. The average annual acreage, production, and farm value of wheat in the ten states leading in production in the five years are shown in Table VII. It will be seen that ten states produce practically twice as much of the wheat raised in this country as all the other states combined.

Table VII. Average annual acreage, acre yield, production, and farm value of wheat in the ten states leading in production in the five years from 1918 to 1922, inclusive.

State	Acreage	Acre yield	Production	Farm value December 1
	Acres	*Bushels*	*Bushels*	*Dollars*
Kansas	9,695,000	13.6	131,389,000	194,742,000
North Dakota	8,805,000	10.4	90,535,000	129,934,000
Nebraska	3,957,000	14.2	56,418,000	78,025,000
Illinois	3,220,000	17.6	56,377,000	91,958,000
Oklahoma	3,559,000	12.9	46,341,000	69,193,000
Missouri	3,396,000	13.3	45,247,000	74,650,000
Washington	2,431,000	16.6	40,686,000	57,386,000
Ohio	2,517,000	15.6	39,600,000	68,021,000
Minnesota	2,920,000	12.7	37,921,000	66,023,000
South Dakota	3,188,000	11.8	37,373,000	58,075,000
All others	20,501,000	14.5	296,825,000	467,617,000
United States	64,189,000	13.8	878,712,000	1,355,624,000



WHEAT PRODUCTION, 1919

STATE	BUSHELS	STATE	BUSHELS
Kans..	148,475,729	Nebr..	57,843,598
Ill....	70,890,917	Ind....	45,207,862
Okla...	65,761,843	Wash..	41,837,909
Mo....	65,210,462	Minn..	37,616,384
N. Dak	61,540,404	Other.	292,893,756
Ohio..	58,124,351	U. S ..	945,403,215

Figure 50.—Map showing the distribution of wheat acreage over the United States 1919. (U. S. D. A.)

Table VII and Figure 51 show Kansas, North Dakota, Nebraska, Illinois, and Oklahoma to be the leading wheat states. These five states produce 43 per cent of the entire wheat crop of the United States. The ten states included in Table VII produce 66 per cent of the entire wheat crop of

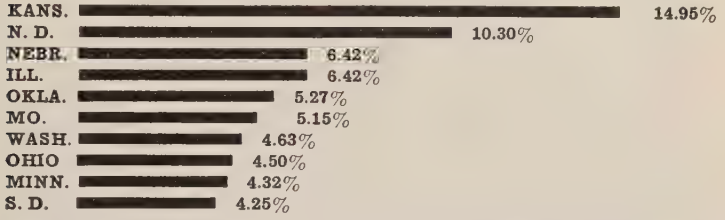


Figure 51.—The percentage of the wheat crop in the United States produced in each of the ten states of largest production, 1918-1922.

the United States, which locates the wheat belt in the North Central states.

The importance of the crop in the various states is best shown by the proportion of the improved farm acreage which is annually devoted to it. Slightly more than one eighth (12.76 per cent) of the improved farm acreage of the United States was devoted to wheat from 1918 to 1922. A larger proportion of the improved farm land was sown to this crop in North Dakota than in any other state, as shown by Figure

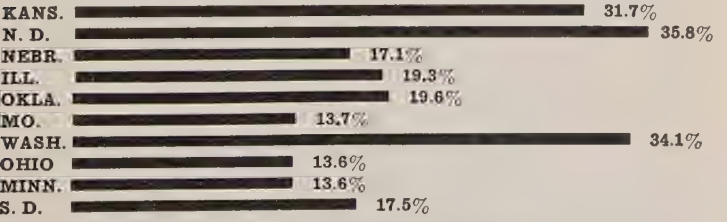


Figure 52.—The percentage of improved farm land which is annually planted to wheat in the ten states of largest production and in the United States, 1918-1922.

52. In Kansas and Washington, one third of the improved farm land was devoted to wheat, and nearly one fifth in Oklahoma and Illinois.

172. Acre Yield. The most important wheat-producing states are by no means the states with the highest acre yields; in fact the reverse is usually true. Of the ten leading wheat-producing states, Illinois holds first place on the basis of acre yield; Washington, second; Ohio, third; Nebraska, fourth; Kansas, fifth; Missouri, sixth; Oklahoma, seventh; Minnesota, eighth; South Dakota, ninth; and North Dakota, tenth. The average yield in the United States in the five years from 1918 to 1922 was 13.8 bushels to the acre. Arizona has the highest average yield for the same period, 24.4 bushels but this is only on about 40,000 acres. North Carolina has the lowest average yield, only 8.6 bushels to the acre. Under favorable conditions, yields of 30 bushels or more may be obtained in most of the states. The average is kept down by poor methods of culture, insects, diseases, storms, and unfavorable weather conditions. The largest yield per acre of wheat ever recorded, so far as ascertained by the Bureau of Crop Estimates, is 117.2 bushels, produced in 1895 on an 18-acre field in Washington. The variety was Australian Club. The field consisted of black sandy loam and clay subsoil and had previously been in pasture and potatoes. The average value of the wheat crop to the acre is not in exact proportion to the yield, for the price per bushel varies greatly in different sections, according to distance from terminal markets. On account of high average yield, the highest average acre value of wheat, as shown by statistics, is shown to have been in Arizona.

SOILS AND FERTILIZERS

173. Soils. Wheat is adapted to a very wide range of soils, and grain of excellent quality is produced on very light as well as on very heavy soils. The type of soil does not seem to affect the crop greatly, either in quality or quantity, so long as the needed plant food and moisture are available. These conditions may be supplied on almost any arable soil,

by good methods of cropping and tillage. As a rule, however, the better the soil the better the yield, unless the land is so rich that the crop lodges before it matures, in which case grain of poor quality is sure to be produced.

The best wheat sections are in that portion of the temperate zones where there is an annual rainfall of from 20 to 40 inches, distributed quite uniformly throughout the growing season. Wheat, however, is grown in the Pacific states, where most of the rainfall comes during the winter and very little of it during the growing season; but soils in this section have great water-holding capacity, which enables them to hold the moisture till it is needed by the crop. Wheat is also grown under irrigation with very satisfactory results.

174. Manures and Fertilizers. Grain is the chief product of the wheat crop. It removes from the farm considerable amounts of nitrogen, phosphoric acid, and potash. Of the mineral constituents of wheat the grain is high in both potash and phosphorus, while the straw contains considerable potash (about 15%) but very little phosphorus (about 3% of phosphoric anhydride). The most of the soils in the wheat belt have a much larger supply of potash than of nitrogen and phosphoric acid, and as the potash is used more largely in the production of straw, which as a rule remains on the farm, nitrogen and phosphorus are first depleted. Where live stock is kept, clover grown, and the land manured frequently, satisfactory yields of wheat may be obtained on naturally fertile soils for generations without the addition of commercial fertilizers. But where wheat is the main crop or where wheat and other exhaustive crops are grown and land is seldom if ever manured, it ultimately becomes necessary to add to the soil some kind of commercial fertilizer that will supply the needed elements as they become deficient. Clover may be grown to add nitrogen, and clover, green manure, and stable manure will maintain the supply of vegetable matter. Where this practice

is followed, about the only element that must be supplied by means of commercial fertilizer is phosphorus.

Experiments have shown that during the first half of its growth wheat appropriates about 85 per cent of its mineral constituents, while during the subsequent period of its growth it is developing its starch and cellulose ingredients which are taken largely from the air. These facts have bearing on the problem of its fertilization.

In the East and South, where the soils have become worn by long continued cropping, commercial fertilizers are usually applied for each crop. Likewise, in some of the Central states the application of commercial fertilizers is becoming necessary in many localities to insure profitable yields. The kind and amount of fertilizer most profitable to apply can be determined only by careful trials in each locality and on each type of soil. A very common practice is to apply at seeding time from 200 to 300 pounds of fertilizer to the acre, containing about 2 per cent available nitrogen, 8 per cent available phosphoric acid, and 2 per cent potash. In many localities, where a supply of vegetable matter and nitrogen is maintained by growing clover and by applying stable manure, the application of either raw or treated rock phosphate is sufficient to provide for satisfactory yields.

GROWING THE CROP

175. Preparation of the Land. The preparation of the land does not differ materially for winter or spring wheat, though the crops are seeded at different seasons of the year. The main object in the preparation of the soil for wheat is to produce a mellow, firm seed bed with sufficient loose soil on the surface to check the rapid evaporation of moisture, and to provide a hospitable place for the plants to grow. Where possible, land is plowed for wheat, though sometimes the crop is seeded on disked corn or stubble land. The better practice is to plow the land. To prepare newly plowed land for

winter wheat seeding, it is necessary to harrow the soil at once very thoroughly, to pack down the lower part of the furrow slice so that it will not dry out. The object of this harrowing is to retain sufficient moisture in the furrow slice for germination, which is not done if the soil is left loose and lumpy. It is also desirable to harrow and disk the plowing

Figure 53.—The disk harrow is one of the most effective tools to use in preparing a good seed bed. Double disking, as shown here, leaves a level surface.

sufficiently to pack the lower part of the furrow slice so that the moisture in the subsoil may be brought by capillarity to the surface, where the grain is planted and the roots begin their growth.

Early plowing is said to yield from 3 to 10 bushels more wheat per acre than late plowing. It also has the advantage that it helps to eradicate weeds.

If spring wheat is to be sown and the land is fall-plowed, it is not desirable to harrow it during the fall. If the soil is left rough, it is acted on more fully by the elements, is in better condition to take up the moisture that falls, holds snow better, and is more easily prepared in the spring than

if it is harrowed smooth in the fall. In the semiarid regions where the soil must be thoroughly cultivated in one season and enough moisture stored in it to grow a crop the following year, the plan just given would not be advisable, for it is necessary to harrow after heavy rains in order to retain the moisture which falls.

To prepare fall-plowed land for wheat in the spring, thorough disking and harrowing are necessary. Spring-plowed land is prepared for spring wheat in the same manner as fall-plowed land for winter wheat.

176. Preparing Seed for Planting. Wheat grown in the vicinity, graded to maximum weight and quality, and free from foul seed, has been shown by numerous experiments to be the best that is possible to obtain for the main crop. On many farms, a great many weed seeds and seeds of grain of inferior quality are sown with the seed wheat. It is not reasonable to expect better grain in the harvested crop than is sown. Wheat grown continuously in one community is often said to run out, and frequently the practice of changing seed grain every few years is followed. This is not the best practice, for it has been shown beyond any question of doubt that if the home-grown grain is carefully graded each year and the best used for seed, it will not run out, but may be gradually improved.

On the general farm, there is not sufficient time to permit the careful breeding and selection of grain as practiced by careful plant breeders; but it is entirely practical to select a small proportion of the best grain by running a quantity of it through a common fanning mill, and in this way to select the heaviest and plumpest kernels.

177. Fanning Mill Selection. Fanning mills separate grain by size and shape of kernel, and by weight of kernel. In some makes of mills one of these methods is employed, and in others both are used. The mill which separates by only one of these means cannot do as satisfactory work as

one in which both are used. With a mill using both methods, the heavy and light kernels of wheat can be separated; the heavy kernels can then be run over a screen of the proper size so that the smaller ones will be taken out and only the larger ones left for seed. In this comparatively easy way the very best seed grain can be obtained.

It is known that in a herd of cattle some individuals are superior to others. It is as reasonable to expect that in a large number of wheat plants or wheat kernels the same variation will be found. Careful observation of a handful of wheat will convince one of this fact. It is probable that in the field where thousands of individual kernels are sown, some of them will be better adapted to the soil and other conditions than others. Those best adapted will naturally make the most perfect growth, and will accordingly produce the most perfect kernels. If the most perfect kernels are graded out by means of a fanning mill, as suggested, then seed from the individual plants best adapted to the field and climatic conditions is obtained. Thus one may easily and rapidly grade seed and maintain it at a high standard, or even improve it.

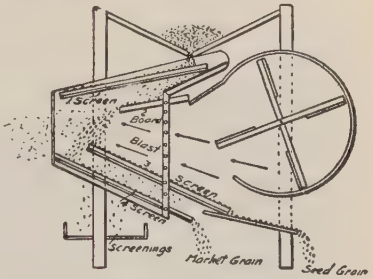


Figure 54.—Diagram of fanning mill, showing a method of grading seed grain. The wind blast from the fan at the right blows the chaff and light grain out at the left; the heavier grain falls on screen 3, through which the smaller kernels fall, leaving the large, heavy kernels for seed.

Seed wheat, cleaned and graded as just suggested and then treated for smut (Section 196, c), is good seed to sow.

178. Obtaining New Varieties. It is often desirable to obtain new and improved varieties of grain. The main part of the crop, however, should be sown with seed graded from home-grown stock, and any new and promising variety tried in a small way for at least two years, in comparison

with such carefully graded seed. Unless the new variety proves superior to the old one under the conditions of the farm, it of course will be better not to change.

179. Sowing. Better results are usually obtained by sowing wheat with the drill than by sowing broadcast. The drill covers all the kernels, as can not be done with a broadcast seeder, and all kernels are placed at a uniform depth. If judgment is used in running the drill, the seed is sown just deep enough to insure sufficient moisture for germination, and not so deep as to make it difficult for the plants to get through the surface soil. When grain is sown broadcast a portion is left on top, where under ordinary conditions it will not grow, and where it is readily picked up by birds. Drilling also insures a more uniform distribution of the seed, and requires less of it.

The amount of seed to sow depends on the variety, its size and germinating power, the method of sowing, soil, and climate. A fair average throughout the United States is about 5 pecks per acre. The amount varies from as little as 2 pecks in parts of California to 8 or 9 pecks in Ohio. About 6 pecks are sown in the spring wheat regions. In general, the heavy clay soils require more and the lighter and warmer soils, with the dry-farming sections, less. It is always safer to sow plentifully, and yet it has been found that the yield is not always in proportion to the amount which is sown.

180. Time of Sowing. The time of sowing winter wheat varies with the locality. It is desirable to sow it early enough so that considerable root growth can be made before winter. In the northern wheat regions, winter wheat is usually sown in September. Farther south, it may be sown much later. Spring wheat, as a rule, does best when sown early in the season. Wheat will germinate at a comparatively low temperature, and a crop of wheat is very seldom injured by cold or freezing weather. On this account

the general practice is to sow wheat as early in the spring as a good seed bed can be prepared. When wheat is sown early, the cool weather of spring causes the development of a heavy root system and induces stooling; while, if it is seeded late, the stems shoot up so quickly that there is little chance for stooling. Other reasons for early seeding are to avoid as

Figure 55.—Plowing, seeding, and harrowing at one operation. A common method of sowing wheat on the large wheat farms of the Western states.

much as possible the ravages of diseases and insects and to avoid the damage of storms, which are usually more severe in the latter part of the growing season.

181. Harrowing. Harrowing after plants are up is not a common practice, though it sometimes gives very good results. Spring wheat is sometimes harrowed after it is up, especially if there is a tendency for a crust to form on top of the soil. Harrowing breaks up this crust by forming a slight dust mulch, which aids in checking the evaporation of moisture and also aids in destroying weeds. Some plants are injured by this practice, which fact no doubt is the reason why the practice is so uncommon. Drilled wheat only should be harrowed and the harrow should be run in the direction of the drill rows and not across them. Of course the grain should be well rooted before it is harrowed.

HARVESTING AND THRESHING

182. Harvesting. With the exception of a considerable acreage in the Pacific states, wheat is harvested as soon as it is ripe, to avoid loss by crinkling and shattering and from storms. East of the Great Plains grain is usually cut with the binder and handled in the bundle. Headers (machines

Figure 56.—Cutting wheat with binders on a North Dakota farm. Note the rape in the wheat stubble in the foreground. After harvest, sheep are turned into the field to pasture on the rape and the gleanings.

that cut off the heads of the standing wheat and elevate them into wagon boxes driven alongside) are used in the western Great Plains area and to some extent west of the Rocky Mountains. In the Pacific states, where there is no rain for several weeks during the harvest season, the grain is allowed to become thoroughly ripe and dry and is then harvested with a combined harvester and thresher, or "combine" (Figure 59). Such machines cannot be used east of the Great Plains area, on account of the unfavorable weather.

183. Shocking Wheat. One of the qualities desired in good milling wheat is bright color. If wheat is exposed

to rain and dew after it is ripe, it loses this desirable brightness. On this account it is the usual practice to shock wheat as soon as it is cut and to cap the shocks so that a large portion of the heads will be protected from the weather and thus retain the bright color of the kernels.

Figure 57.—A well-built wheat shock which will withstand storms and in which the grain is well protected from weathering.

There are two types of shocks well adapted to the protection of wheat. The one known as the 9-bundle round shock is made by setting up a pair of bundles and then setting another pair so that they lean against opposite sides of the first two. This will make a 4-bundle shock, one bundle at each corner. The next four bundles are set against the first four, just filling the open spaces between the bundles. The whole is then capped with one bundle which is spread out at both the top and butt ends to cover as much of the shock as possible. Care must be exercised in placing the cap bundle that the butt end does not extend out over the side of the shock so that the wind can get under the bundle and blow it off. It is not so likely to blow a bundle off the head end, because the heads are heavy enough so that when the shock is settled they will lie down against the shock.

The other type of shock is known as the 12-bundle shock. This is made by setting three pairs of bundles in a row against one another, usually setting the long way of the shock north and south; then the two open spaces on each

side of the shock are filled by placing two bundles against each side. Two bundles are used for the cap. These bundles are laid lengthwise of the shock, and care is taken so that the butts of the bundles do not extend out over the shock. This is a very good form of shock for any kind of grain. Figure 57 shows a well-built shock. It is worth while to build shocks in the best way possible.

Figure 58.—Stacks of wheat awaiting the threshing machine. A better quality of grain is usually obtained from stacking than from threshing from the shock.

184. Stacking. Much of the wheat grown in the United States is stacked before it is threshed. A stack is usually made by starting a round shock and continuing to lean bundles against it until a bottom of the desired size is made. The stack is then built up by laying the bundles horizontally in tiers beginning from the outside, the inner tiers lapping over the next outer tier, thus holding the stack together. A grain stack is usually built up quite level for the lower 6 to 10 feet. Each outer tier of bundles is extended out over the stack a few inches so that the stack is larger in circumference at a height of from 4 to 8 feet than it is on the ground. This projection is called "the bulge." The bulge permits the outer edge of the stack to settle more than the center, which gives a slant to all outer bundles so that they may shed water. When the stack has been laid out to the size

and height desired, the middle is then filled quite full, by putting in additional courses of bundles, so as to give a good slant to all the outside bundles. Each succeeding outside tier is then drawn in from 4 to 6 inches farther than the tier next under it. In this way the stack grows gradually smaller as it gets higher, until it is finally finished in a nicely rounded

Figure 59.—Combined harvester and thresher drawn by traction engine.

peak. The top bundles are usually held in place by pushing a stick 8 or 10 feet long, sharpened at both ends, down into the center of the stack. Sometimes an inverted bundle, with the band near the butt, is put down over the sharp stick, as the final cap of the stack. In some cases the peak is covered with a forkful of hay. Care must be taken not to make the top of the stack too steep, as it may be blown off.

185. Threshing. Wheat may be threshed from the shock or stack as desired. Threshing from the shock is cheaper, and is desirable if one can get the threshing machine at the proper time so the work can be done as soon as the grain is in fit condition. On farms of moderate size, where the threshing is hired, it is seldom possible to get the machine just when desired. The difference in cost is not sufficient to warrant taking chances of injury to the grain by bad weather, and it is better to stack wheat as soon as it is dry enough after cutting than to take chances by waiting for a machine.

When wheat is stacked, it goes through what is called a sweating process; that is, it warms up slightly, becomes moist, and the straw gets tough and remains so for two to

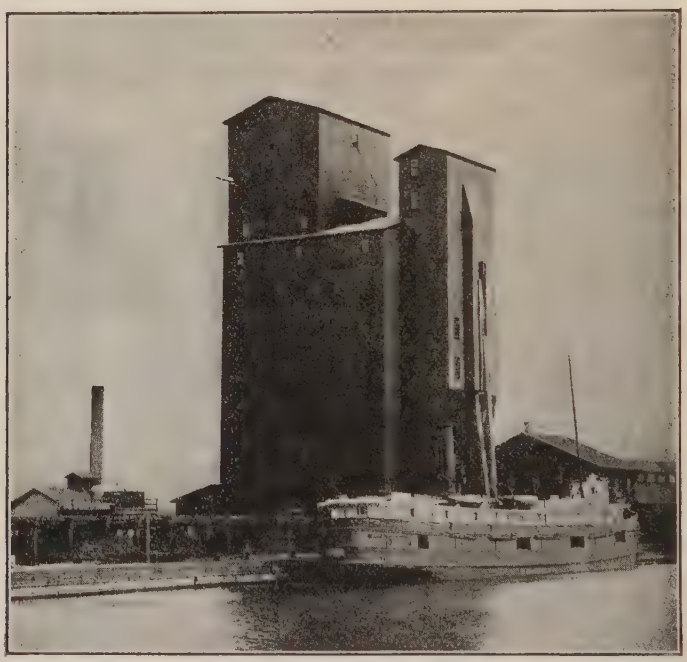


Figure 60.—An elevator where wheat is stored and from which it is loaded into boats for shipment.

three weeks. Wheat is believed to have a slightly better color if allowed to go through this sweating process in the stack. On this account many persons prefer to stack their wheat before it is threshed.

186. Storing. Wheat may be satisfactorily stored in any bin or room that will protect it from rain, if it is dry when stored. If wheat is threshed soon after it is cut, it will sweat in the bin, and in that condition it is not safe to put large quantities of the grain in one place, for it is likely to

heat and be injured in quality. After grain has been stacked for three or four weeks, it has then gone through this "sweat," and may be safely stored in large bins.

As wheat is a dry grain, it does not usually lose more than 2 or 3 per cent from shrinkage in storage.

Much grain is sold from the farm soon after it is harvested. This is largely held in elevators until it is needed for milling or export.

An interesting treatment of storage in elevators is found in The Book of Wheat. See State and Federal laws.

MARKETING AND MARKET GRADES

187. Marketing. It is usual to market the crop soon after it has been threshed. Farmers occasionally hold their wheat for several months in the hope of getting better prices, but this practice as a rule does not prove profitable. There is considerable shrinkage in storage, due to loss of moisture, pilfering by mice, leakage, etc. The interest on the money invested must also be considered. If one takes into account shrinkage, interest, and cost of storing facilities, one is likely to lose more times by holding than to gain. A revision of our present marketing system might make some difference.

Of late years there has been a very wide agitation for the co-operative marketing of wheat on a national scale, but this problem has not yet been fully worked out, although considerable progress has been made in the Northwest and the Southwest.

188. Grades. In accordance with the United States Grain Standards Act, the market grades of wheat are fixed by the Secretary of Agriculture. The grades effective July 17, 1922, divide wheat into five classes, hard red spring, durum, hard red winter, soft red winter, and white. The hard red spring class is divided into dark northern spring, northern spring, and red spring subclasses; the durum class into amber durum, durum, and red durum subclasses; the hard red

winter class into dark hard, hard, and yellow hard winter subclasses; the soft red winter class into red winter and western red subclasses; and the white class into hard white, soft white, and western white subclasses. Each of these subclasses is then divided into six grades, No. 1, No. 2, No. 3, No. 4, No. 5, and Sample. The full descriptions of the grades in one class will be sufficient illustration of the differences between the various grades.

Class III. Hard Red Winter, shall include all varieties of hard red winter wheat, and may not include more than 10 per cent of other wheat or wheats. This class shall be divided into three subclasses as follows:

Dark Hard Winter. This subclass shall include wheat of the class Hard Red Winter consisting of 80 per cent or more of dark, hard, and vitreous kernels.

Hard Winter. This subclass shall include wheat of the class Hard Red Winter consisting of less than 80 per cent and more than 25 per cent of dark, hard, and vitreous kernels.

Yellow Hard Winter. This subclass shall include wheat of the class Hard Red Winter consisting of not more than 25 per cent of dark, hard, and vitreous kernels.

No. 1 wheat of each of these subclasses (a) shall be bright, cool, and sweet; (b) shall have a test weight per bushel of at least 60 pounds; (c) may contain not more than 13.5 per cent of moisture; (d) may contain not more than 1 per cent of foreign material other than dockage, which 1 per cent may include not more than one half per cent of matter other than cereal grains; (e) may contain not more than 2 per cent of damaged kernels, which may include not more than one tenth of 1 per cent of heat damaged kernels; and (f) may contain not more than 5 per cent of wheat other than hard red winter, which 5 per cent may include not more than 2 per cent of white, and durum wheat, either singly or in combination.

The lower grades of dark hard winter, hard winter, and yellow hard winter wheat differ from No. 1 just described in having (1) a lower bushel weight, (2) a higher percentage of moisture, (3) a higher percentage of foreign material, (4) and a higher percentage of damaged kernels. The minimum bushel weights for the five grades (Nos. 1, 2, 3, 4, and 5) are 60, 58, 56, 54, and 51 pounds, respectively. The maxi-

mum percentages of moisture allowed are 13.5, 14, 15, 15.5, and 15.5, respectively. The percentages of foreign material other than dockage are 1, 2, 3, 5, and 7, of which ½, 1, 2, 3, and 5 per cent may be matter other than cereal grains. Likewise, the allowable percentages of damaged kernels, heat damaged kernels, and of other wheats increase relatively through the different grades. Sample wheat of any of these subclasses is wheat that does not come within the requirements of any of the grades, has an objectionable foreign odor, is sour or heating, or is otherwise of low quality.

The requirements for the different grades in other subclasses are similar to those just given, though the weights and percentages for the same grade (No. 1, for instance) in the various classes are not necessarily the same. The full descriptions of the grades occupy 16 pages in the bulletin in which they were originally published.[1]

PRICES AND COST

189. Exports and Imports. The principal countries having a surplus of wheat for export are, Russia, Argentina, Canada, the United States, Roumania, and Australia. The total world exports of wheat and wheat flour averaged 723,000,000 bushels annually for the five years from 1909 to 1913, inclusive. Of this amount, Russia exported 155,000,000 bushels; Argentina, 93,000,000 bushels; Canada, 86,000,000 bushels, and the United States, 84,000,000 bushels, or about one eighth of the annual crop. The principal importing countries are the United Kingdom, Germany, Belgium, the Netherlands, and Italy. The United Kingdom imports 209,000,000 bushels annually, or about two sevenths of the total imports of the world.

190. Prices. The average farm price of wheat on December 1 in the United States for the ten years from 1913 to 1922 is given by the United States Department of Agriculture

[1]Handbook of Official Grain Standards for Wheat, Shelled Corn, and Oats, U. S. Dept. Agr., Bureau of Agricultural Economics, 1922.

as $1.39 per bushel. The price varied during that period from 80 cents in 1913 to $2.15 in 1919. The average farm price on December 1, 1921 was 92.7 cents and on December 1, 1922 it was $1.01. The price fell very rapidly in the fall of 1920. The farm price of wheat varies considerably in different sections of the United States, depending upon the local supply and demand and the distance from market. In the North Central states west of the Mississippi River, including Minnesota, Iowa, Missouri, North and South Dakota, Nebraska and Kansas, the 10-year average farm price is between $1.30 and $1.42 per bushel. This section produces about one half of the wheat crop of the United States. In the North Atlantic states, which include only about 4 per cent of the wheat acreage of the United States, the average farm price for the same period was $1.50 per bushel. In the Far Western states, representing about 10 per cent of the wheat area and about 13 per cent of the total production of the United States, the average price was about $1.32 per bushel.

191. Cost of Production. The cost of producing wheat naturally varies with the section of the country, the rental value of the land, the price of labor, and the methods employed. From reports made by more than five thousand correspondents of the Bureau of Crop Estimates of the United States Department of Agriculture, tabulated in the May, 1911, Crop Reporter, the average cost of producing an acre of wheat in 1909 in the United States was $11.15. Of this total, the average amount expended for fertilizers was 58 cents; preparation of the land, $2.11; seed, $1.42; planting, 46 cents; harvesting, $1.33; preparing for market (including threshing), $1.48; miscellaneous, 47 cents; land rental or interest on land value, $3.30. As the average yield in that year was 17.2 bushels, the cost of production was 66 cents a bushel. The average value of wheat was 96 cents a bushel, leaving a return of 30 cents a bushel, or $5.33 an acre. While

these figures are merely estimates and are now far too low, the large number of reports which are included make them of considerable value. A presentation of the acre value, acre cost, and value less cost for the different sections, as shown in Table VIII, is of interest.

Table VIII. Acre value, acre cost, and value less cost of production of wheat in various sections of the United States in 1909, as reported by correspondents of the Bureau of Crop Estimates.

Section	Acre value	Acre cost	Value less cost
	Dollars	*Dollars*	*Dollars*
North Atlantic	21.18	17.05	4.13
South Atlantic	16.83	13.10	3.73
South Central	14.05	10.35	3.70
East North Central	18.31	13.41	4.90
West North Central	14.96	9.74	5.42
Far Western	22.01	12.69	9.32
United States	16.48	11.15	5.33

In recent estimates of cost of production, the total cost is divided into six items, man labor, horse labor, materials, threshing, use of land, and miscellaneous items. In most sections, use of land is by far the largest single item. The miscellaneous items include taxes and insurance, use of tractors and other farm machinery, loss on abandoned wheat acreage, and other minor expenses. On the average, this group of items ranked next to use of land in amount, followed by man labor and horse labor, the cost of which averaged about the same. Materials include seed, twine, fertilizer and manure. The total cost of production in 1919 in nine counties in Nebraska, Kansas, and Missouri where surveys were made ranged, on the average in these counties, from about $23 to almost $40. The cost on individual farms naturally had a much greater range than this. In the spring wheat region, the average cost in five counties in which surveys were made ranged from about $18 to about $23, but the cost per bushel was higher than in the winter wheat region, as very low yields of spring wheat were obtained in 1919.

According to figures[1] published in 1918 the average cost of cutting an acre of wheat with the binder varies from 88 cents to $1.17, according to the width of cut of the binder used, the lower cost being for the 8-foot cut and the higher for the 6-foot. The average cost of cutting with the binder is $1.02, and of shocking, 21 cents per acre, making a total of $1.23 for harvesting and shocking. To this must be added the cost of stacking, about $1.00 to the acre. The cost of heading and stacking, in sections where the header can be used, ranges from $1.06 to $1.38, according to the size of the outfit used. The total cost of cutting and threshing wheat with the combined harvester and thresher ranges with outfits of various sizes from about $1.50 to $2.25 per acre. As the cost of threshing must be added to the harvesting costs given above for the binder and the header, it can readily be seen that the combine is the most economical machine for harvesting wheat, but its use is of course limited by climatic conditions to a comparatively small part of the wheat acreage.

RELATION TO OTHER CROPS

192. Place in the Rotation. Wheat is one of the best crops to use as a nurse crop for grasses and clover, because it is sown early, at the time when grass seed starts best, and because it does not shade the ground so much as oats or barley. On this account, wheat commonly follows corn and precedes a hay crop. In the main wheat-producing sections, it is very commonly grown year after year on the same land, without fertilization. Occasionally such land is left without a crop for one year and summer fallowed; that is, it is plowed once or twice, usually about midsummer. This is a wasteful practice, unless it is followed for the purpose of conserving moisture. Otherwise, it is usually discontinued as a country develops and some system of crop rotation is introduced.

[1]Dept. of Agr. Bul. 627, Cost of harvesting wheat by different methods.

A very simple rotation is: First year, corn; second year, wheat; third year, clover. Such a rotation is adapted to light soils or to building up run-down soils. This is especially true if the corn and grass crops are fed to stock and the manure returned to the soil. Another common rotation is one covering five years: First year, wheat; second year, hay; third year, pasture; fourth year, corn; fifth year, oats. Such a rotation is suitable where all the land is tillable, where the grass crops may be grown, and where diversified farming is practiced. In the Southwest, where difficulty is experienced in getting grass started and where alfalfa is the main hay crop, the following rotation is often followed: First year, corn; second year, wheat; third year, oats. To add a vegetable matter to the soil, cowpeas or soy beans are seeded as soon as the grain crops are removed, and plowed under later in the fall. In the South, a common rotation is: First year, corn and cowpeas; second year, wheat and cowpeas; third year, cotton. In the tobacco sections of the South, a rotation often followed is: First year, tobacco; second year, wheat; third year, clover.

193. Wheat as a Nurse Crop. In sowing grass seed with wheat, it is quite often mixed with the seed grain and sown, and in other cases it is sown with a grass seed attachment on the drill or seeder. Timothy seed may be sown with winter wheat in the fall when the wheat is seeded, but as a rule it is much safer to sow clover seed in the spring than in the fall. Grass seed may be seeded in the spring on winter wheat land, and the land harrowed to cover it, without detriment to the crop.

USES OF WHEAT

194. As Human Food. The chief use of wheat the world over is for flour to be used as human food. It contains more gluten than other grains, which, on account of its elastic dough, makes it preferable for bread making. There are

numerous grades of flour, but only three general kinds; namely, white flour, graham flour, and whole-wheat flour. White flour is by far the most generally used. Graham flour differs from whole-wheat flour only in that it is the whole wheat ground and unbolted, while the coarser part of the bran is removed from the whole-wheat flour. Contrary to general belief, white flour makes more digestible bread than either the graham or whole-wheat flour. Durum, or macaroni, wheat is manufactured into flour (*semolina*) for the manufacture of macaroni and other similar products. Bread from it is very palatable, but not quite so light or white as from ordinary white flour. Shredded whole wheat and cream-of-wheat are breakfast foods made from wheat. Whole wheat is sometimes cooked thoroughly and eaten as a breakfast food.

195. As Feed for Live Stock. Wheat is usually too valuable to feed to stock. Some of the poorer grades and wheat screenings are often fed, however, and occasionally the prices of live stock and of wheat are such that good wheat may be fed profitably. The by-products in the manufacture of flour,—namely bran, shorts, middlings, and often the poorer grades of flour commonly called red-dog,—are very common and valuable feeds for live stock. Table IX shows the general composition of some of these by-products as compared with corn.

Table IX. Digestible nutrients in pounds to the hundred pounds of dry matter of wheat and the by-products from flour mills, compared with corn.

Feed	Protein	Carbohydrates	Fat
	Pounds	*Pounds*	*Pounds*
Corn	7.8	66.8	4.3
Wheat	8.8	67.5	1.5
Bran	11.9	42.0	2.5
Shorts	13.0	45.7	4.5
Middlings	16.9	53.6	4.1
Red-dog flour	16.2	57.0	3.4

It will be observed that wheat and all the mill by-products are richer in protein than corn, while corn is richer in carbohydrates than any of the wheat products.

DISEASES AND INSECT ENEMIES

196. Diseases. It is very seldom that a crop of wheat is matured without being affected to some extent by some of the common diseases to which the crop is subject, as scab, rust, and smut. There are other diseases, but so little is known about them that only the three named will be discussed here. Disease causes an immense loss to wheat and other cereal crops every year, whereas considerable might be done to check this loss.

(*a*). *Scab.* Scab is a fungous disease which attacks the glumes, or chaff, of the wheat plant. It sometimes results in much loss, causing the kernels to shrink. Sometimes only a few glumes are affected, and these are identified by pinkish spots at the base. Scab also attacks the germinating seeds and often kills or dwarfs the young plants. Sowing clean seed and growing wheat after some crop other than wheat or corn help to prevent losses from scab.

(*b*). *Rust.* Rust occasionally causes immense damage to wheat over large areas. It is a fungous disease which is almost always present to some extent, and which, when conditions are favorable, may spread rapidly and cause the straw to become very weak, resulting in shrunken kernels. There are two kinds, the leaf rust and the stem rust. The former is nearly always present, but the latter is by far the more destructive. Stem rust spores live over winter on the ripened plant, and go from there to the common barberry in the spring, where another kind of spores is formed. The spores which go through the winter on wheat or other grain straw can not infect the growing grain, but those from the barberry infect grains and grasses. Some varieties of wheat are more resistant to rust than others, Kanred being a par-

ticularly rust-resistant hard winter wheat. Good drainage and the use of early varieties which escape rust damage are also helpful in reducing losses from this disease.

A helpful method of prevention of black stem rust is the eradication of the common barberry, which is cultivated for ornamental purposes and which acts as a host by harboring the spring spores of this disease. It is estimated that in the three spring wheat states alone the loss from black rust amounted in 1916 to nearly $180,000,000. A single plant or hedge in a city may give off spores that will travel by means of grasses to fields at a distance. The common barberry, however, should be distinguished from the Japanese variety which does not harbor or propagate the disease. The common barberry is an upright shrub, 4 to 8 feet high, with grey bark, branched thorns, leaves with spiny margins, and berries, borne in clusters like currants. The Japanese is a low, spreading shrub, 2 to 4 feet high, with reddish brown bark, single thorns, smaller leaves with smooth edges, and with only one to three berries in a place. A concerted campaign is being carried on by the U. S. Department of Agriculture and thirteen North Central states to remove the plant entirely and prevent the great economic losses caused by it.

Figure 61.—Common barberry on the left, and Japanese on the right.

(*c*). *Smut.* Smut is a fungous disease which attacks the wheat crop and causes very heavy loss. The smut plant grows within the wheat plant and produces masses of spores in the head where the kernels of grain should be produced. The whole head is generally attacked, and usually all the heads of a plant, which latter fact is a strong indication that

the infection comes from the seed, or enters the plant at a very early stage in its growth. There are two kinds of smut that attack wheat, the loose smut, which destroys the entire glume and kernel, leaving the rachis naked, and the stinking

Figure 62.—Stinking smut of wheat. Notice in the open grains how the smut spores have destroyed the whole interior.

smut, which simply produces within the apparently healthy glumes a smut ball in place of a kernel of wheat. Both these smuts are very destructive.

Stinking smut is controlled by treating the seed before sowing. The most simple and practical method is to moisten the wheat with a solution made by mixing 1 pint of 40 per cent formaldehyde with 45 gallons of water. Wheat may be dipped in the solution in baskets or loosely woven sacks. It may be run through the solution by means of a smut machine, or the solution may be sprinkled over the seed by means of a sprinkling can, the wheat being shoveled over

several times during the process to insure the thorough moistening of each kernel. The smut spores are on the outside of the kernels, and all that is required is to bring the solution in contact with them. Loose smut is very difficult to handle, as the spores get into the open flowers and become enclosed within the wheat kernel. The only treatment that is effective is the modified hot water treatment, which is extremely difficult to apply. The wheat is soaked for four hours in cool water, because heat will pass through the kernel more quickly when it is wet. It is then soaked for ten minutes in water at 129 degrees Fahrenheit. It is not advisable, without a great deal of experience, to treat much seed in this way, as the germination of the grain is likely to be lowered or destroyed. Treat only enough for a seed plat, and get clean seed for the main part of the crop in this way.

197. Insect Enemies. There are several insects which occasionally cause great damage to the wheat crop. Only the more important will be discussed. These include the Hessian fly, chinch bug, grasshopper, and army worm.

(*a*). *The Hessian fly* resembles the mosquito quite closely. It lays its eggs in the growing wheat. When the maggots hatch, they work in the lower part of the stem, weakening it and causing the head to fall over so that it is missed by the binder. Fall plowing, rotation, and burning straw, stubble, screenings, and litter are all effective methods of checking the loss from this insect.

(*b*). *Chinch bugs* often destroy much wheat by sucking the sap from the plants. They are blackish in color, with white wing covers, and are about one fifth of an inch long. They live over winter in the mature form, under rubbish and leaves. In the spring the females lay their eggs; a little later, the young appear as very small, reddish bugs. The hatching period extends over several weeks, and so bugs of all sizes may be seen at one time. There are no effective remedies against these bugs in wheat, except to burn or otherwise dis-

pose of all rubbish in the fall, so that the bugs will have fewer places in which they may be able to hibernate.

(*c.*) *Grasshoppers* when abundant, often do great damage to wheat. The eggs are laid in the ground during midsummer, and hatch the following spring. The young hoppers have no wings; hence they do not travel about much. When full grown they acquire wings and fly readily. The eggs are usually laid in pastures, meadows, and in waste land. Late fall plowing and rotation of crops are effective in controlling the hoppers, for many of the eggs are destroyed and others are buried so deep as to prevent the young hoppers from getting to the surface when hatched. The young hoppers are often destroyed in large numbers, by use of hopper-dozers, or by poisoning with arsenite of soda.

(*d.*) *Army worms* sometimes injure the growing crop, while grain weevils are destructive to the stored grain, especially in the South. These insects and the remedies for them have already been discussed (Section 146).

METHODS OF IMPROVEMENT

198. Wheat Will Not Mix. Wheat, being close-fertilized, is one of the comparatively easy crops to improve, because selected plants do not become mixed with undesirable ones, as is the case with corn. It is probable that occasionally some cross-fertilization occurs, but it is so seldom as to be unimportant. If several varieties of wheat are grown in one plat, any one plant will produce pure seed regardless of the plants surrounding it. This fact enables one to use large numbers of individual plants in improvement work.

199. Breeding by Selection. The most common method of improving wheat is by selection. A large number of wheat plants grown under perfectly uniform conditions will vary greatly in yield and in other respects. Advantage should be taken of this fact in breeding by eliminating all the poorer plants, and reproducing only those capable of

giving the best returns. A very common method is to grow on uniform land from one thousand to several thousand plants of the variety of wheat to be improved. At harvest time, twenty-five or fifty of the highest-yielding plants are saved, and the seed from each plant kept in a separate package. With the seed from each of these selected plants, separate plats are planted to test their ability to continue to give large yields. This comparative test is continued for at least three years; the plant giving the highest average yield for three years in the small plat is increased as rapidly as possible, to furnish seed for the main crop.

200. Crossing. As wheat plants are close-fertilized, crossing artificially is often practiced. To do this, the unopened anthers are removed from the florets and the head is covered for a couple of days until the stigmas are ready to be fertilized. Ripe pollen is then taken from another head and dusted on the stigmas of the head from which the anthers are removed. The head is again covered to prevent any other pollen from reaching it. On account of the fact that wheat is not naturally cross-pollinated, crossing in this way causes a great variation in the resulting plants. The crossing of two varieties of wheat may bring forth plants similar to either parent and many variations from either of the original types, as for example, bearded wheats may result from a cross between beardless varieties. The object of crossing is sometimes to unite desirable characters in two varieties, and sometimes to cause a greater variation than is common, with a view to having greater opportunity for selection. It takes several generations to fix the character of a wheat plant produced by crossing. A few desirable varieties of wheat have been produced in this way, but by far the greater number are the result of straight selection.

201. Judging Wheat. For the purpose of judging seed wheat, the agricultural colleges have devised score cards giving varying values to the important points desired.

While these colleges do not all agree as to the relative importance of each point, they do agree quite uniformly on the important points. Any of these cards will serve the purpose of calling attention to the important points that must be considered in judging.

SCORE CARD FOR SEED WHEAT

SALIENT POINTS	INTRINSIC POINTS	Standard Score
YIELD 30 Points	Weight per bushel	25
	Uniformity	5
VARIETY CHARACTERS 15 Points	Color	3
	Purity	10
	Kernel Shape	2
VITALITY 30 Points	Luster	5
	Plumpness	15
	Germ	3
	Odor	7
MARKET CONDITION 25 Points	Weed seed	10
	Dirt and dust	3
	Injured kernels	2
	Smut, etc	5
	Condition of bran	5
100 Points	Total	100

LABORATORY AND FIELD EXERCISES

1. Obtain samples of as many kinds of wheat as possible, and learn to identify them. Note differences in weight, size and shape of kernel, hardness of kernel, and color.

2. Obtain samples of wheat from several farms; compare weight, color, percentage of weed seeds, percentage of dirt, purity of sample (that is, is it one pure variety or a mixture?), size and variation of kernels, presence or absence of smut.

3. Obtain an average sample of wheat; weigh out carefully one or two ounces; count the kernels, then determine the number in one pound, in one bushel. Find how many kernels per square foot there would be if 1¼ bushels were sown evenly on an acre of land. If possible, count the number of plants found growing on one square foot in a good field of wheat. How do you account for the difference?

4. Visit several fields of grain just as they are heading out. Find a head of wheat that is smutted; pull up the plant on which the smutted head is growing, and carefully examine all the heads on the plant, even if you must split the stem open to find some of the heads that have not yet appeared. Examine several smutted plants in this way. Are all the heads of a plant usually smutted, or are only part of them?

Does not this indicate that the infection came from the seed instead of spreading in the field?

5. Obtain two small samples of wheat. Sprinkle one with water, just as you would do if treating for stinking smut as suggested in this chapter. After treating the sample, allow it to stand for from ten to fifteen hours. Then plant several kernels from both the treated and untreated samples in a box of sand. Slightly moisten the sand as you ordinarily would if you wished the wheat to germinate; keep the box in a suitable place for wheat to germinate. Note the difference in germination between the treated and untreated seed.

6. Get a sample of wheat affected with stinking smut. Learn to identify the smut balls. Does the sample show indications of being smutted either by looks or by smell?

7. Go into a field at harvest time or early in the fall; dig up some wheat stubble, also some stubble from a timothy and clover meadow. Compare the amount and character of the roots of the three kinds of plants. Which crop will leave the most vegetable matter in the soil?

8. Some time between January 1st and planting time, obtain samples of wheat from a number of farms. Place 100 kernels from each sample in plate germinators. Compare the strength and percentage of germination.

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1301. The Common White Wheats.
1303. The Club Wheats.
1304. The Durum Wheats.
1305. The Soft Red Winter Wheats.

CHAPTER V

OATS

HISTORY AND DESCRIPTION.

202. Origin and History. The oat belongs to the genus *Avena*, one of the numerous subdivisions of the great family of grasses, the *Gramineae*. As nearly as can be determined, this plant is a native of central or western Asia and eastern Europe, probably within what is now Russia. No mention is made of oats in the earlier writings which have been preserved, and there is no evidence that this grain was cultivated until a much later period than wheat and barley, though it was known among the Greeks and Romans. It is not strange that the ancient peoples, with their crude methods of grinding and preparing grains for use as food, first cultivated wheat, which threshes free from the hull, and barley, with a hull much thinner than that of oats. Oats probably were not grown till the need for feed grain for domestic animals became a pressing one, and were then used for human food only when other grain crops failed. Their hardiness and quick maturity brought them into favor in some of the northern countries, where they have long been used as food for man as well as for live stock. The early colonists introduced oats into America, and their cultivation soon became common, particularly in the more northerly sections.

Practically all the cultivated varieties of oats have been developed from the form known as *Avena sativa*, though a few, such as the Red Rustproof of the Southern states, have probably been derived from *Avena sterilis* or some other wild form native to southern Europe or northern Africa. Several species of *Avena* are now found wild in

various parts of the world, and one, the common wild oat, *Avena fatua*, is a serious weed pest in grain fields in the northern United States and in Canada. None of the closely related genera or species is generally cultivated, though velvet grass (*Holcus*) and tall oat grass (*Arrhenatherum*) are occasionally sown with other grasses for meadow and pasture purposes.

203. Botanical Characters. The oat is an annual plant with hollow, jointed stems and fibrous roots. The culms are from 2 to 5 feet in height, the average being about 3½ feet. The number of culms produced from a single seed is usually from three to seven, though the height of the plant and the number of culms depend very largely on the richness of the soil, the thickness of planting, and the season. The leaves are numerous, lanceolate, 6 to 12 inches long and ½ to 1½ inches wide. The base of the leaf, or sheath, clasps the culm for practically the entire length of the internode.

The flowers are borne in panicles, which are more or less spreading according to the variety. The panicle consists of a central stem, or rachis, with from three to five whorls of several small branches each arranged at intervals along it. It is usually from 9 to 12 inches long, and bears from forty to seventy-five spikelets. Each spikelet consists of two or more flowers, of which usually but two are fertile. In some varieties, only one grain reaches full size, though usually two grains develop, the second being smaller than the first. Occasionally the third flower in the spikelet produces a grain, but this is usually too small to be of value. The flowers are enclosed in two thin outer glumes (the chaff), while the reproductive organs of each flower are enclosed in the flowering glume and palea, which later form the hull. The organs of reproduction consist of three stamens with thread-like filaments, tipped with large anthers, and a pistil with two feathery stigmas. The flowers open for only a few hours; fertilization generally takes place before they

open. The oat is normally close-fertilized, though cross-fertilization may possibly occur.

The seed varies in size, color, and shape according to the variety, but is usually two or three times as long as broad, tapering from a little above the base to the tip, and is furrowed on the inner side. The flowering glume is often provided with a short, usually twisted awn, which is attached to the back of the glume. This may fall off when the grain ripens or be broken off in threshing, or it may adhere to the threshed grain. In the form known as hull-less oats rarely grown in this country except as a curiosity, the grain separates readily from the flowering glume, and threshes out clean like wheat.

Figure 63.—Oat spikelets in blossom.

The weight of the grain in ordinary oats is one third to one half the weight of the entire crop, and about two thirds of the weight of the grain is kernel and one third hull. Some samples run as high as 75 per cent of the kernel, while others do not exceed 60 per cent.

204. Classification of Varieties. The varieties of hulled, or common, oats may be divided into two classes, according to the arrangement of the branches on the rachis, (the central

stem of the panicle). If these are all about the same length and turned to one side, the variety belongs to the class of side, or "horse-mane," oats; if the branches are of different lengths and stand out at different angles from the rachis, they are of the spreading, or "sprangled," type. The latter is much more common, whereas side oats include only a few varieties, grown generally in the more northerly sections. As with wheat, there are winter and spring oats, according to their adaptability to fall seeding. Winter oats are much less hardy than winter wheat, and are seldom grown in this country except in the Southern and Pacific states. Oats may be divided according to the color of the hull into white, yellow, black (gray or brownish-black) and red (reddish-brown) varieties. The oats commonly grown in the North are white, though black and yellow varieties are sometimes sown; those grown in the South are red or gray in

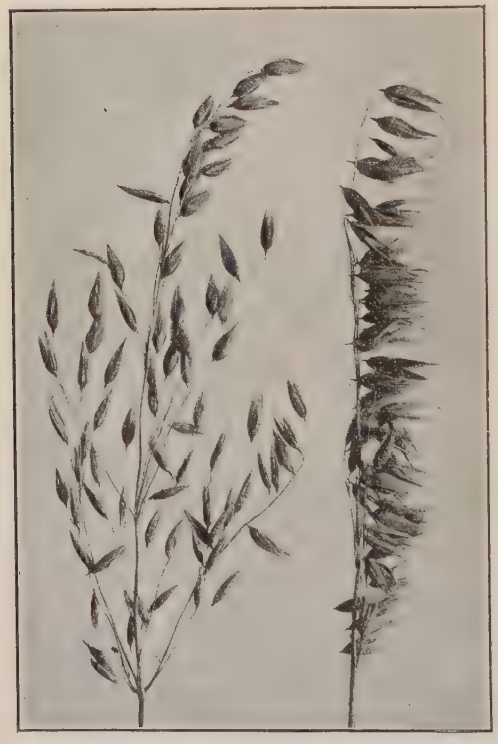

Figure 64.—The two types of panicles in oats; spreading at the left; side, or "horse-mane," at the right.

color. Another division may be based on the time of ripening, as early, midseason, and late; and still others on the size and the shape of the grain. Early oats ripen in 90 to 100 days from sowing, and late oats in from 115 to 130 days.

205. Leading Varieties. The differences in time of ripening, shape of grain, and other characteristics are so slight as

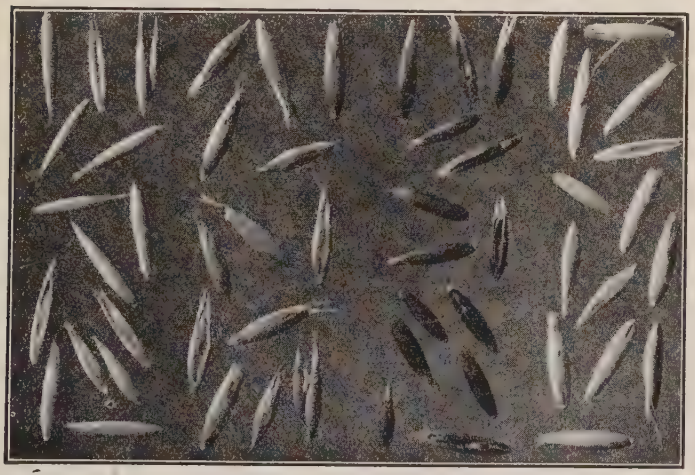

Figure 65.—Four varieties of oats differing in size, shape, and color. On the left, an early yellow oat with small, slender grains, Sixty Day; next, a plump, large-grained, reddish-brown variety, Red Rustproof; then a small, black oat, North Finnish Black; on the right, a medium late, large, white variety, Swedish Select.

to make the classification and identification of varieties extremely difficult. New varieties are introduced each year by enterprising seedsmen, and old ones are sent out under new names, thus adding to the confusion. A few of the more prominent varieties of white oats grown in the Northern states are Big Four, Silvermine, Clydesdale, Swedish Select, and American Banner. White Tartar (White Russian) is the most common variety of the side-oat type. Farther south, particularly through Nebraska, Iowa, and Illinois, a small early yellow oat from southern Russia known as the

Sixty Day, or Kherson, is coming rapidly into favor, though Silvermine, Green Russian, and later oats are popular in some sections in these states as well as in those farther east and north. In the South the most common varieties are Red Rustproof, Fulghum, Burt, and Winter Turf. The first two may be sown in the fall or in the spring, but Winter Turf only in the fall and Burt only in the spring.

IMPORTANCE OF THE CROP

206. World Production. Oats grow best in a cool, rather moist climate, and are most largely produced in the North Temperate zone. Among the leading countries in the production of this crop are the United States, European Russia, Germany, France, Canada, Poland, and the United Kingdom. Such northern countries as Sweden and Norway also produce large quantities of oats, but they are not important factors in the world production on account of their comparatively small area. According to the figures of the Bureau of Agricultural Economics of the United States Department of Agriculture, the world production of oats is about 4,000,000,000 bushels annually, or somewhat more than that of corn or wheat. On account of the much greater weight of a bushel of either of the other grains, the total weight of those crops is considerably more than that of oats, and the value is also much greater.

In the five years from 1910 to 1914, the average annual production of oats in the United States was 1,158,000,000 bushels, or a little less than one fourth of the world production. European Russia averaged 928,000,000 bushels in the same period; Germany, 596,000,000 bushels; Canada, 365,000,000 bushels, and France, 309,000,000 bushels.

207. Production in the United States. In the United States, oats rank second to corn in the number of bushels of grain produced, but are exceeded in total weight by wheat as well as by corn. In value, they rank fifth among our

field crops, falling below corn, cotton, hay, and wheat. The average annual area devoted to the production of oats in the United States in the five years from 1918 to 1922 was 42,677,000 acres; the average annual yield, 30.6 bushels to the acre; average total production, 1,302,454,000 bushels; and average farm value on December 1st, $683,411,000. The ten leading states in the production of oats are shown in Table X.

Table X. Average annual acreage, acre yield, production, and farm value of oats in the ten states of largest production in the five years from 1918 to 1922 inclusive.

State	Area	Acre yield	Production	Farm value December 1
	Acres	*Bushels*	*Bushels*	*Dollars*
Iowa	5,929,000	35.7	210,941,000	95,688,000
Illinois	4,317,000	33.7	146,005,000	74,966,000
Minnesota	3,735,000	33.2	122,868,000	53,299,000
Wisconsin	2,446,000	38.1	92,526,000	48,543,000
South Dakota	2,256,000	31.0	69,005,000	28,680,000
Nebraska	2,411,000	28.0	67,070,000	29,302,000
Indiana	1,786,000	32.0	58,517,000	31,164,000
North Dakota	2,489,000	23.0	57,139,000	22,738,000
Ohio	1,543,000	34.2	53,116,000	30,109,000
Michigan	1,540,000	31.2	48,247,000	26,253,000
All others	14,225,000	26.5	377,080,000	242,669,000
United States	42,677,000	30.6	1,302,454,000	683,411,000

As shown by Table X and Figure 66, the leading states in the production of oats are Iowa, Illinois, Minnesota, Wisconsin, and South Dakota. These five states produce nearly half of the entire oat crop of the country, while the first four, comprising the central portion of the upper Mississippi Valley, produce more than 570,000,000 bushels, or about one seventh of the entire production of the world. The percentage of the total crop of the United States produced by each of the important states is shown in Figure 66.

More than 17 per cent of the total farm area of Iowa and nearly 13 per cent of that in Illinois is annually devoted to the production of oats, while more than 10 per cent of the

total farm areas of Wisconsin and Minnesota are utilized for this purpose. A more reliable basis for comparing the relative importance of the oat crop in the various states is that shown in Figure 67, in which the percentages of the total improved farm area annually sown to oats in the ten leading states are shown. These percentages are based on the annual acreages as shown in Table X and on the acreage of improved farm land as shown by the Census of 1920. The diagram shows that oats are relatively more important in Iowa and Wisconsin than in any other state, more than one fifth of the improved farm land being sown to this crop in Iowa and nearly one fifth in Wisconsin. The oat crop is sown on about one sixth of the improved farm land of Illinois and Minnesota, and on smaller proportions of the other six states. Nearly 8.5 per cent of the entire acreage of improved farm land in the United States is annually devoted to the raising of oats.

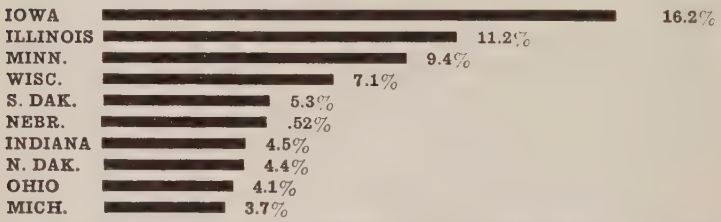

Figure 66.—Graph showing the percentage of the total oat crop in the United States produced in the ten states of largest production in the five years from 1918 to 1922, inclusive.

208. Acre Yield. The states which rank highest in acre yield are those in which the acreage is comparatively small, both because large areas still remain to be developed within their borders, and because oats are grown almost entirely on irrigated land, which comprises only a small proportion of the total acreage. The combination of favorable climatic conditions, including abundant moisture supplied at the right time in their development, makes oats a very produc-

tive crop in these states. The average yield to the acre for the five-year period (1918-22) in Washington was 40.4 bushels and in Idaho, 38.8 bushels. In comparison with these figures, the average yield for the entire United States was 30.6 bushels to the acre, while that of the five states of largest total production ranged from 31.0 to 38.1 bushels. Naturally, much higher yields than any of these averages indicate are obtained in all the states. Returns of from 150 to 200 bushels to the acre have been recorded in some of the North Pacific and Rocky Mountain states, while in the upper

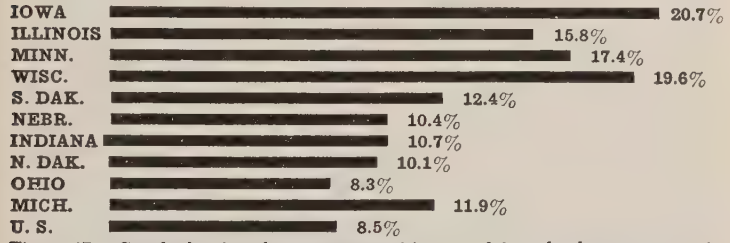

Figure 67.—Graph showing the percentage of improved farm land sown to oats in each of the ten states of largest production and in the United States during the five years from 1918 to 1922, inclusive.

Mississippi Valley crops of from 50 to 75 bushels to the acre are obtained in favorable years. The average, however, is kept down by unfavorable seasons, and by the crops grown on poor soil and on poorly prepared land. Adaptation of variety, and proper selection of soil suitably prepared will help to raise the average.

THE PRODUCTION OF THE CROP

209. The Best Soils for Oats. The best soils for oats are those which warm up early in the spring, thus aiding early seeding and germination, and helping to mature the crop before hot weather. As oats draw more heavily on the soil moisture than most of the other grain crops, a good oat soil is also one that holds moisture well. This combination is found in the loams and clay loams; heavy clays are too

cold, while light sandy soils are too likely to dry out when the crop is in the greatest need of moisture. A fairly good crop can be produced on almost any reasonably fertile land, however, if other conditions are right. Some of the heaviest yields are obtained on the muck soils of Washington.

The oat plant is a comparatively shallow feeder, most of its roots being found in the first two feet of soil. For this reason, the best crops are produced on fairly fertile soil, though on rich land there is always a tendency toward rank growth of straw, particularly if the moisture supply is abundant. This rank growth and abundant moisture invite such diseases as rust and mildew, and the weak, soft stems are unable to support the weight of the crop, hence lodging follows. If lodging takes place early in the season, the grain will be light and shriveled. Lodging when the grain is nearly ripe usually does little damage to the crop, though the cost of harvesting may be greatly increased. Lodging at this time is more likely to be due to the blowing over of the entire plant during a heavy rain storm than to weakness of the straw. Attempts are being made to produce oats which are resistant to the tendency to lodge, but the most effective means of preventing lodging are thorough drainage and the use of land that has not been freshly manured.

210. Manure and Fertilizers. It has just been stated that the land should not be too rich for oats. It is best to apply barnyard manure to some other crop in the rotation, such as corn or grass, allowing the oats to get some of the benefit of the residual effect of the manure. When commercial fertilizers are necessary, those containing phosphorus and potassium as the principal elements should be used, except on soils which are decidedly lacking in nitrogen. On such soils, plowing under a leguminous crop for green manure before sowing the oats is frequently of much benefit. This is most necessary and can be done to best advantage in the South, where oats are sown in the fall. On soils which are

lacking in potassium, the use of fertilizers containing that mineral usually greatly increases the yield, and at the same time tends toward the production of stiffer straw. In general, where the use of commercial fertilizers is necessary, the largest yields are obtained from the application of small

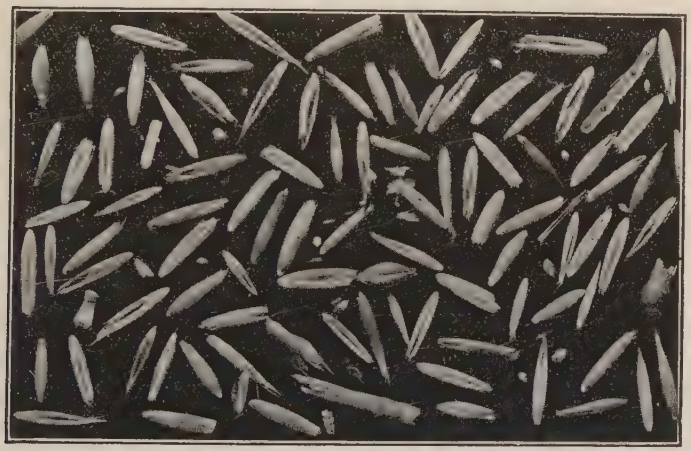

Figure 68.—A sample of oats as it came from the threshing machine; weight, 30 pounds to the bushel.

quantities of a mixture of all three of the important fertilizing elements, nitrogen, potassium, and phosphorus.

211. Preparing the Land. As early seeding is desirable in order to have the crop mature before hot weather, the preparation of the seed bed should begin just as soon as the land is in condition to work in the spring. A mellow, rather loose surface soil with a firm subsoil is best for oats. On fields where a cultivated crop was grown the previous season, this is most quickly and easily obtained by the use of the disk and smoothing harrows. If the soil is naturally rather loose or if the field had been plowed for the preceding crop, such as corn or potato land, just as good yields are often obtained by disking without plowing as from any

other method of preparation. Generally, where it is possible to do the work, fall plowing followed by spring disking and harrowing will produce the largest yields most economically, because soils so prepared are usually in the best shape to store up moisture for the use of the crop. Spring plowing

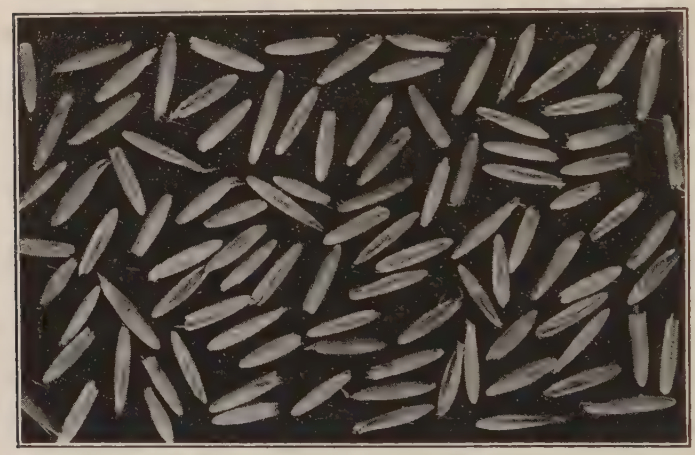

Figure 69.—Some of the largest and heaviest grains out of the same lot as the sample shown in Figure 68. Weight, 39 pounds to the bushel.

frequently delays seeding, and unless the soil is thoroughly packed to firm the lower layers, it is likely to be too loose for the best results.

Where oats follow some other small grain, the land is quite generally plowed; but in the corn belt, where oats are most largely grown, they are usually sown on the corn land without plowing. The common practice is to disk the ground thoroughly in the spring, making a mellow seed bed to a depth of 3 or 4 inches, fining and smoothing the surface with the spike-tooth harrow. In this way, very good results may be expected at reasonable cost. In some cases, oats are sown broadcast on land that has been neither disked nor plowed, the only preparation given being the disking or

cultivating necessary to cover the seed. This is a cheap but a very slovenly method of farming, which, while it may occasionally produce good returns, is quite likely to result in reduced yields because it does not put the soil in proper condition for the germination of the seed or the retention of moisture for the growth of the crop.

212. Preparing the Seed for Planting. It is even more important to grade seed oats before sowing than seed wheat, for in most years there is a larger proportion of weak, shrunken kernels in oats than in wheat. These kernels are slow in germinating, or do not grow at all. The plants produced from them are small and weak, and never yield so well as those from large, plump kernels. Oats very frequently contain a considerable proportion of weed seeds, chaff, and dirt, all of which tend to reduce the stand by lessening the quantity of good seed which is sown. Thorough cleaning of the seed with the fanning mill or by some other means is advisable, and usually pays well for the necessary time and labor. Treating the seed with a solution of formaldehyde before sowing will destroy oat smut (Section 237). Details of the treatment have already been given (Section **196,c**).

213. Time for Sowing. Oats should be sown as early in the spring as the ground can be put in condition, for usually the plants are not seriously injured by late frosts, and best results are obtained when the crop makes as much growth as possible before hot weather. All tests which have been made by the experiment stations favor early seeding. The exact date of seeding naturally depends on the locality and the season. Seeding may be entirely finished during an early spring at an earlier date than it can be begun in a backward one. In general, the best date from Kansas eastward is during the latter half of March. In Nebraska, Illinois, Iowa, and other states in the same latitude, the first half of April is usually the seeding season, though in exceptional years seeding may be finished before April 1, or may be

delayed until almost May 1. In the Dakotas, Minnesota, Wisconsin, and other states along the northern border, the usual seeding season is the latter half of April, though it may extend well into May or be finished by April 20. Fall-

Figure 70.—Sowing oats with a broadcast seeder on corn land without previous preparation. A careless method of farming.

sown oats are sown in September in North Carolina, Tennessee, and Arkansas, and in October farther south.

214. The rate of seeding varies in different sections as well as on different soils and with different varieties. The usual rate is from 2 to 3 bushels to the acre, though in some sections it is considerably greater, while in the "dry-farming" region of the West, from 1 to 1½ bushels is the usual rate. In England and Scotland, 6 to 7 bushels to the acre is sometimes sown; such heavy seeding is almost never practiced in this country. Numerous experiments in the upper Mississippi Valley show that there is little difference in the yield either of grain or straw when from 2 to 3 bushels is sown, but that the yield of straw increases while that of grain decreases at rates of less than 2 bushels. Within reasonable limits, the number of culms produced from thin seeding will be as great as from thick seeding, as thin seeding induces

abundant tillering, especially in the drier and warmer soils.

215. Seeding Implements. Oats are now sown with a broadcast seeder or with the grain drill. Up to a few years ago large acreages of oats and of other grains were sown broadcast by hand and the seed covered with the disk harrow, spike-tooth harrow, or cultivator. This practice is still quite common in some sections, except that the broadcast seeder has been substituted for the old method of scattering the seed by hand. Seeding with the grain drill is usually regarded as the most profitable and satisfactory method of sowing oats, for all the seed is covered to a uniform depth, less seed is required, and the yields are usually better. Uniform depth of covering is an aid to uniform germination and growth; in broadcast seeding, some of the seed may not be covered at all, some may be at the best depth, and some may be covered too deeply. Less seed is required for sowing with the drill, since there is no loss from seed which fails to grow on account of too much or too little covering. The yield is usually better on account of the more uniform stand and growth and the more uniform distribution of the plants. It is claimed that drilling produces two to six bushels more per acre than broadcasting.

216. The proper depth to cover the seed depends to some extent on the nature of the soil and the climatic conditions. Seed should be covered somewhat more deeply in loose, sandy soil than in compact clays or clay loams. In semi-arid regions where the surface soil is likely to dry out, deeper seeding is necessary than where plenty of moisture is available. In general, covering to a depth of from 1 to 2 inches will give best results.

217. Harrowing. Harrowing oats after they are up is often recommended as a means of saving moisture by breaking the crust and lessening evaporation, and also as a means of destroying weeds. Harrowing is most profitable in the drier portions of the country, and on drilled oats. Harrow-

ing oats which were sown broadcast destroys a part of the plants and thus lessens the stand. Drilled oats should be harrowed in the direction of the drill rows and not across them. The roller may be used instead of the harrow while the plants are small. After the plants are too high to work with the harrow, cultivation may be continued for some time by using a light weeder. One or two cultivations are about all that are usually profitable, and in sections where the rainfall is sufficient for the best growth of the crop, even these may be an added expense without adequate return. The only good then accomplished is the destroying of weeds.

218. Irrigation. In the Rocky Mountain and Pacific states, large acreages of oats are grown under irrigation. The depth of water which is applied generally ranges from 15 to 20 inches; that is, sufficient water to cover the soil to this depth if all were applied at the same time. Usually, however, the water is put on in two or three applications, and is applied so slowly that it soaks into the soil within a few hours after the supply is shut off. Water is generally supplied about the time heading begins and again when the grain is filling, though sometimes the land is irrigated before or immediately after seeding.

HARVESTING THE CROP

219. Cutting. There is little or no difference in the methods of harvesting oats and those which have already been given for harvesting wheat. The crop is usually cut with the binder, though occasionally the header is used in some of the drier sections. When the straw is very short, due to continued dry weather, the crop may be cut with the mower, raked into shocks and handled like hay. It may then be stacked and threshed the same as grain in bundles, or it may be fed in the straw like hay. The only difference is that if it is to be fed as hay, the crop should be cut before it is fully ripe, as many of the leaves will be lost in handling

if the grain is allowed to mature, and the straw will not be of as good quality for feed. Grain which is cut with the mower should be handled as little as possible to avoid shattering. Oats should not be cut till they have passed the hard dough stage, or the yield will be reduced and the grain will be green and shrunken. The best time to cut is just before the heads turn yellow, as the filling of the grain will then be completed in the shock and there will be no loss from shattering. Winter oats in the South are harvested in the latter part of May and the first half of June. The harvesting of spring oats is begun in Texas and the other Southern states in June, and is completed in the North about September 1. Oat harvest in Illinois and Iowa is in the month of July.

Figure 71.—A good shock of oats.

220. Shocking. Oats cut with the grain binder are usually set up to cure in shocks of ten or twelve bundles. As with other grains, the bundles should be set firmly on the butts and the shocks built well to avoid as much as possible the danger of blowing over in storms. Much of the value of the crop depends on the way it is shocked, for poor shocking exposes the grain to the weather and causes it to be greatly damaged in color and quality by hard rains. It really makes little difference whether the long or the round

shock is built, if the shock is properly set up and capped. In wet weather bundles may be set up and capped later.

Oats are often put into shocks without capping, but this exposes all the grain to the weather, when nearly all could be protected by putting a little more time into the operation. The cap consists of one or two bundles laid on the top of the shock to form a protecting cover. These bundles should be firmly placed and so laid that they will protect as large a part as possible of the heads of the bundles in the shock. If two bundles are used in capping, the head of one should overlap the head of the other. The long shock is to be preferred for grain that is not fully ripe or that contains a considerable proportion of weeds, because it allows a better circulation of air and dries out better than the round shock.

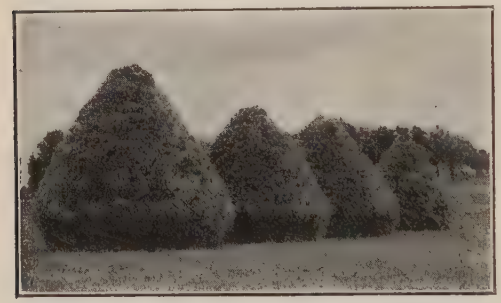

Figure 72.—A setting of well-built stacks of grain.

221. Stacking. It is usually advisable to stack oats, though threshing from the shock is a very common practice in some sections. If good weather for several weeks after harvest could be assured, and a threshing machine could always be obtained when desired, there would be little objection to the practice of leaving oats in the shock until threshing time. Frequently, however, continued rains prevent threshing and cause much damage to grain which is left unstacked. A better quality of grain is almost always obtained if oats are stacked about ten days or two weeks after harvest. Stacking and threshing costs about one cent a bushel more than threshing from the shock; the choice

between the two systems depends largely on the season and the locality, as well as the circumstances of the time.

If the grain is stacked, it should be left in the shock to cure for a week or ten days, after which it should be hauled to a convenient place near the barns for stacking. The straw can then be placed where it can be used most advantageously. The grain should be dry when stacked, as it is likely to mold if damp. The bottom of the stack should be built of old rails or some similar material to raise it a few inches off the ground and prevent the absorption of moisture from the soil. The conical stack is preferable to the long rick which is sometimes built, for it sheds water rather better. Whatever form is built, the bundles should be so laid that all the grain is protected from weathering.

222. Threshing. If grain is to be threshed from the shock, the threshing should be done as soon as possible after the bundles are well cured, thus lessening the time in which it can be damaged by bad weather. Stacked grain should be allowed to stand for at least two weeks before threshing, and a longer time is even better. The grain goes through a sweating process both in the shock and in the stack, and should not be threshed until this is about completed. When threshed from the shock, it should be thoroughly dry, or much of the grain will not be removed by the thresher. Properly stacked grain is ready for threshing within a few hours after a rain, or as soon as the exposed portions of the bundles have dried off.

Attention should be given to the threshing machine to insure the removal of all the grain from the straw, and to see that the grain is thoroughly cleaned of chaff and dirt. Threshing machines in good order can do a very thorough job in both these respects if properly regulated. The straw should be put up in good stacks or run into the barn, for it is too valuable to take chances on having it spoiled by poor stacking and bad weather.

223. Storing the Grain. Oats are sometimes hauled direct from the threshing machine to the elevator and sold, but by far the greater part of the crop is stored to be used on the farm or to be sold at some later time. More than two thirds of the oats grown in the United States is fed on the farms where they are grown. Clean, tight bins are necessary for the proper storing of this grain. These should be placed well above the ground, where there is no possibility of the grain's absorbing moisture from the soil. They should be separated by a tight partition from the portion of the barn where live stock is kept, to prevent the absorption of moisture from the stable. The storage bin, however, should be located near the place where the grain is to be fed, to avoid extra labor in handling. In the Southern and Central states, where grain is frequently destroyed by grain weevils and moths, storing in tight bins with covers of sheet iron or matched lumber is almost necessary in order that the grain can be fumigated. Some means of keeping mice and rats out of the bins should be provided, if possible.

MARKETING AND RETURNS

224. Market Grades. The market grades for oats are less strictly adhered to than those for wheat and comparatively little difference is made on the market between clean, bright grain and that which contains considerable quantities of chaff, dirt, and weed seeds, or is discolored. Usually this difference is not enough to pay the farmer for cleaning his grain, though it does justify him in demanding proper separation and cleaning by the threshing machine. The market grades of oats depend on color, weight, and freedom from other grains, heat-damaged kernels, weed seeds, and dirt. The commercial grades are Nos. 1, 2, 3, 4, and Sample in white, red, gray, black, mixed, bleached, or clipped oats. Most of the oats sold on the market is No. 2 or No. 3. Usually there is a difference of 1 or 2 cents a bushel between any

particular grade and the one next below of the same color. White oats ordinarily sell higher than mixed or colored oats. Bleached oats are oats, usually discolored from weathering, which have been artificially bleached to improve their appearance. Clipped oats have been run through a machine which clips off the long tip of the hull. They weigh about 3 pounds to the bushel more than unclipped oats otherwise of the same grade. The legal weight of a bushel of oats in most states is 32 pounds; in Canada it is 34 pounds. The weight of a measured bushel varies, ranging from 20 pounds or less in unfavorable years in the South to 40 pounds or more in Montana, Washington, and other Northwestern states.

225. Exports and Imports. Only about 2 per cent of the oat crop is normally exported, and in some years the export trade falls to almost nothing. During the war, however, about 100,000,000 bushels were exported annually. Very small quantities are imported. The imports usually consist of grain from Canada or northern Europe for seed purposes, though importations have been made from Argentina.

226. Prices. The price of oats per bushel depends on the supply not only of this crop but of other grains, and on the local demand. The average price of oats on the farm on December 1st for the ten years from 1913 to 1922, for the entire United States, was 49.5 cents per bushel, ranging from 30.2 cents in 1921 to 70.9 cents in 1918. The highest average price is to be found in the North Atlantic and Southern states, from 60 to 85 cents a bushel. In the Pacific states the price is but little lower, while in the upper Mississippi Valley where the bulk of the crop is raised, the average price in 1922 was 35 to 40 cents.

The value of an acre of oats depends naturally on the yield and the value per bushel. The highest values are found in the Rocky Mountain and Pacific states, where high yield and high price are combined; but as most of this grain is grown under irrigation, the cost of production is also high.

Figure 73.—Threshing grain from the shock. This practice is a good one where dry weather may confidently be expected during the harvest season, but elsewhere it is likely to result in loss of quality.

High values are also prevalent in New England. In the South, the high price makes up in part for the low yield, so that the acre value is about as high as the average for the entire country. The lowest acre values are found in the states of largest production, where medium yields are combined with low price per bushel. The average value per acre for the entire United States for the years from 1916 to 1920 was $20.32. In 1921, however, it was only $7.16, and in 1922 it was $11.76. The acre value in North Dakota in 1921 fell as low as $3.99, due to a combination of low yield and low price. In Iowa, the state of largest production, it was $5.52 in 1921 and $11.36 in 1922.

227. Cost of Production. Data on the cost of producing an acre or a bushel of oats are less numerous than those on the cost of producing corn and wheat. As for those crops, the cost varies widely with the price of labor, the use of fertilizers, the charge for the use of land, and other items. The average of nearly 100 records taken in Wisconsin show that about 15 hours of man labor and 24 hours of horse labor are required to grow and harvest an acre of oats, with an average yield of 36 bushels to the acre. To this numerous other items, such as land rental or interest on the value of the land, cost of seed, twine, fuel for threshing, etc., must be added. Where the fields are smaller, as in the eastern states, the labor requirements are greater, while in the sections where the land is level and the fields large less labor is needed.

Careful surveys made at various times and places show the cost of producing an acre of oats to range from $7.11 an acre in the Red River Valley of Minnesota to $44.00 on irrigated land in Colorado. The Minnesota records were taken at a time when land, labor, and other items were much lower than at present. The Wisconsin records already referred to, taken at various times from 1907 to 1918, show an average cost of $13.21 to the acre, or 37 cents to the bushel.

In a survey made in 1909 by the Bureau of Statistics of

the U. S. Department of Agriculture, farmers reported costs averaging $10.91 to the acre, or 31 cents a bushel. The average farm value of the crop at that time was 40 cents a bushel, leaving a net return of 9 cents a bushel, or $3.17 an acre. The items of expense recorded in that survey, with the average cost of each, were land rental, $3.78 an acre; preparation of the land, $1.88; preparing for market (threshing, grading, etc.), $1.51; harvesting, $1.34; seed, $1.12; and other items, including fertilizers and seeding, $1.28. To the average net return of $3.17 an acre should be added the value of the by-products, which at that time was figured at $1.42, making a total profit of $4.59 an acre.

The cost per bushel in 1909 in the five states of greatest production was: in Iowa, 29 cents; Illinois, 30 cents; Wisconsin, 31 cents; Minnesota, 28 cents; and Nebraska, 30 cents. These figures show a margin of from 5 to 11 cents net profit when compared with the farm prices for the same year. When the value of the by-products is added, the net return per acre was $3.34 in Iowa; in Illinois, $3.79; in Wisconsin $6.24; in Minnesota, $3.93; and in Nebraska, $2.09.

These figures show that there is ordinarily little profit in growing oats where low average yields are obtained, particularly when the value of the straw is not taken into consideration. It is probable that crops of oats of less than 25 bushels to the acre are usually produced at a loss, though in the South the high value per bushel sometimes returns a profit from yields of 20 bushels or even less.

RELATION TO OTHER CROPS

228. Place in the Rotation. In Iowa, Illinois, and the other states of the corn belt, oats usually follow corn. A common rotation where winter wheat is not grown in this section consists of two crops of corn, followed by a crop of oats and one or more crops of grass or clover. In Maine, Minnesota, and other states where potatoes are an important

crop, a common rotation consists of one crop each of potatoes, oats, and clover. In the South, a good rotation which includes winter oats and the two most important crops of the Southern states, corn and cotton, is as follows: First year, cotton; second year, corn, with cowpeas sown in the corn; third year, winter oats sown after the corn is removed, and followed with cowpeas to be cut for hay. All these rotations include a leguminous crop to add nitrogen to the soil. In the grain-growing sections of Minnesota and the Dakotas, where no regular rotation is practiced, oats usually follow wheat. Better yields are obtained where oats follow wheat than the reverse in a rotation which includes both crops; that is, that corn, wheat, oats, is a better sequence than corn, oats, wheat.

Figure 74.—Oat smut; normal head at the left, smutted head on the right.

229. Use as a Nurse Crop. Oats are largely used as a nurse crop. The practice of seeding to grass and clover with oats is a very common one. While this method of attempting to establish a meadow or pasture is so often used, it is not always successful. As oats draw heavily on the soil moisture and also shade the ground closely, barley and wheat, which take less moisture from the soil and make less

shade, are better nurse crops. Oats start growth early in the season, and on account of their dense growth are a fairly good crop to clear the land of weeds. Barley is rather better, however, since it matures earlier in the season, and is cut before many of the weeds have matured their seeds. If oats are used as a nurse crop, an early variety should be sown, and it should be seeded thinly.

230. Sowing with Other Grains. A rather common practice among some farmers, particularly in Canada and in some of the Northern states, is to sow oats with some other small grain crop, as barley or wheat. In Canada, the most common combination is oats and barley. Experiments show that larger yields of grain in total pounds are produced from a combination which is about half barley and half oats than from either alone. In order to have the two grains mature at the same time, a rather late barley and a medium early oat are necessary. In Minnesota and some other states, wheat and oats are often grown together. While the oats and barley grown in mixtures in Canada are usually fed together on the farm or sold as feed, on account of the difficulty of separating the two grains, mixtures of wheat and oats are frequently taken to elevators to be separated, the oats being then returned to the farm and the wheat sold. It is doubtful whether the increased yield from this combination is sufficient to pay for the expense of separation, but where all the grain is fed on the farm, the growing together of varieties of barley and oats which ripen at the same time often increases the profits from these crops.

THE USES OF OATS

231. Feeding to Stock. By far the greater part of the oat crop is fed to live stock, principally to horses. Oats have long been regarded as the best grain feed for horses, and while corn has rather largely replaced them for this purpose in recent years on account of its larger yield and rela-

tively lower cost, they are still in high favor among horsemen. For feeding to other stock, oats are commonly mixed with corn, if used at all. They are an excellent grain for dairy cattle and sheep. The hulls make them objectionable for feeding to hogs, because the small stomachs of these animals are not able to hold enough of this grain to allow them to utilize it to advantage. Ground oats mixed with swill make an excellent mash to feed to brood sows, however, and are highly recommended by hog raisers.

In feeding value, oats compare very favorably with wheat, in spite of the fact that they contain a much larger proportion of crude fiber (the hull). In protein content they are slightly lower than wheat but higher than barley or corn, containing 9.2 pounds to 100 pounds of dry matter. They are rather low in carbohydrates, 47.3 pounds in 100, as compared with 65 to 69 in the other grains; but contain as much fat as corn, 4.2 pounds, and more than double the quantity found in wheat or barley. Oats are a muscle-building rather than a fattening feed, and are more valuable for animals at hard work, like horses or dairy cows, than for fattening animals, like beef cattle. On account of the mineral matter they contain, which is largely utilized by animals in the formation of bones, as well as the protein, which is the muscle-building element, oats are an excellent feed for young and growing animals of all kinds. They are largely used by poultry raisers, particularly for feeding to flocks which are kept for egg production.

232. Use as Human Food. Oats have been long used as food in Scotland, but have only recently come into common use in other countries. In Scotland, oats are generally used as groats (the hulled grain soaked and eaten raw, or cooked in the form of mush or of thin cakes) rather than in the form of flakes or rolled oats so common in this country. Oatmeal when properly cooked is the best and cheapest of the cereal foods. Long cooking is necessary to make diges-

tible all the protein it contains. Oatmeal and other oat products are occasionally used as a partial substitute for wheat flour in bread making.

233. Oat Straw. The only by-product resulting from the production of the oat grain is straw, which is largely used for feeding to stock as roughage. Oat straw is higher in feeding value and is more readily eaten by stock than the straw from any other grain. It is practically equal to corn stover (cornstalks with the ears removed) for feeding. It is too bulky for feeding to fattening animals or those at hard work, except as a small part of the ration, but as a maintenance ration to "winter over" stock, it is excellent when fed with a little good hay or some grain. Straw which is not utilized for feed is commonly used as bedding for animals, a purpose to which it is well adapted, for it absorbs liquids readily and soon decays in the manure. As it is less harsh than the straw of other grains and is free from beards, it is to be preferred for this purpose. The fertilizing value of a ton of straw at present prices is so high, that no one can afford to burn it. Where it is not possible to utilize the straw either as feed or bedding, it will usually pay to spread it on the land and plow it under to add vegetable matter to the soil.

234. By-Products of Milling. The by-products of the oat milling industry are not very important, since they constitute only a small part of the grain by-products. Quite frequently the oat hulls, light oats, and oat dust are ground with corn and sold as corn-and-oat feeds. These feeds are decidedly variable in their character, depending very largely on the proportion of oat hulls they contain, and should be carefully examined before a purchase is made. Ground corn and oats make an excellent feed, but it should not contain an unusually large percentage of oat hulls, showing the addition of this refuse to the whole grain.

235. Oats for Hay and Pasture. If oats are cut before the grain matures, while the leaves are still green and the

straw is soft, hay of excellent quality can be made. Field peas are frequently sown with oats when the crop is to be cured into hay or is to be cut green for feeding. Peas add to the yield as well as to the feeding value of the crop. A common rate of seeding is 1 bushel of peas and 1½ bushels of oats to the acre. Oats and peas may also be used as pasture for stock of all kinds where permanent pasture is lacking. Hogs should not be turned in on this pasture until the peas have made considerable growth, as they will quickly destroy the young plants. Sheep and hogs will make good use of both peas and oats if not turned on the crop until it matures.

INSECTS AND DISEASES

236. Insect Enemies. Several of the insects which are troublesome in wheat are also destructive to oats, though this crop is seldom seriously injured by insect pests. Among the more troublesome insects in oats are the army worm, chinch bug, green bug, or grain aphis, and the grasshopper. Except in years of specially heavy damage, it is usually not profitable to attempt to destroy insects in oat fields, for the expense of killing them is greater than the damage they do. The means of combating chinch bugs which are given under wheat (Section 196) are equally applicable for oats and other crops. The most destructive insects in stored grains are the Angoumois grain moth and the various grain weevils. Oats, on account of the protection given by the hull, are less frequently damaged by these insects than wheat, rye, or barley. Placing the grain in tight bins and fumigating with carbon bisulphide or hydrocyanic acid gas is recommended where these pests are common.

237. Diseases. The most common and destructive diseases which attack the oat crop are the rusts and smuts. The rusts are of two kinds, usually known as the leaf rust and the stem rust, from the portions of the plant which they most commonly attack. The leaf rust of oats is well known to

everyone, on account of the abundance of its brick-red spores on the leaves and stems at harvest time in years favorable to its development. The stem rust of oats is very similar to the stem rust of wheat, appearing as black spots or blotches on the leaves and stems shortly before the grain ripens. The stem rust is rather less common than the leaf rust, but when it occurs it injures the crop more seriously. Both these rusts are very common in the South, appearing practically every year. In the Northern states, where climatic conditions are more favorable to the growth of oats, rust injury is decidedly less frequent. It is most likely to occur in wet seasons, when the growth of the crop is rank. Oats on rich, wet land are particularly likely to be infected. The conditions favorable to the development of this disease are soft, rank growth, damp, cloudy weather or heavy dews; and land which is particularly retentive of moisture. No effective remedies have yet been discovered. Some varieties or strains of oats appear to be more rust-resistant than others, and plant breeders are attempting to develop this quality to a still greater degree. As conditions favorable to rust are most likely to occur late in the growing season, early varieties often escape rust attacks which do serious damage to late oats. The best preventive measure is to sow early varieties on well-drained land which is not too rich, thus avoiding as much as possible the danger of too rank growth and the moist conditions so conducive to the development of rust.

Oat smut is also of two kinds, the loose and the covered. These smuts differ but little in appearance, and their life histories are practically the same. The spore enters the growing point of the plant about the time of germination, and the slender threads of the smut fungus develop in the tissues of the plant along with its natural growth. The smut reaches its mature form in masses of black, powdery dust, or spores, which replace part or all of the oat head. In loose smut the chaff as well as the grain itself is replaced by

the smut masses, while in covered smut the chaff remains in its natural state, enclosing the smut spores. Smutted heads mature before the healthy ones, and as the straw of the diseased plants is usually shorter, the smutted heads are not readily seen at harvest time and the actual damage from the disease is usually underestimated. It probably averages 2 or 3 per cent of the crop, or from $6,000,000 to $10,000,000 annually for the United States. In some fields it may destroy as much as half the crop. Fortunately, both kinds of oat smut are easily and cheaply controlled by the use of the formaldehyde solution (Section 196, c). This treatment is so cheap and so entirely effective that farmers cannot afford to neglect it. Seed should be treated at least as often as every alternate year, and treatment every year is much safer. Even though all the smut on a given farm may be destroyed, it is pretty certain that some of the spores will be scattered through the threshed grain, having been carried from neighboring farms in the threshing machine, so that treatment every year is the surest way of keeping down this disease.

IMPROVEMENT OF THE CROP

238. Opportunities for Improvement. Until recently the oat crop received less attention from plant breeders and farmers in America than corn and wheat. Some European breeders have devoted their efforts to the improvement of oats and have obtained remarkably good results. Some of the best varieties of oats now grown in the United States, particularly in the northern portion, have been produced by Swedish and English plant breeders. Several of our experiment stations have lately given considerable attention to oat breeding, and some high-yielding strains have been developed.

Qualities which breeders aim to combine to a greater or less extent are increased yield, increased size of individual grains, greater weight per bushel, greater proportion of kernel to hull, earlier maturity, and greater resistance to lodg-

ing and disease. Most of these factors operate in one way or another to increase the total yield. Early maturity is particularly desirable in the Southern and Central states, so that the grain may ripen before the hot summer weather, which is unfavorable to the growth of this crop. An increase in the proportion of kernel to hull is specially desired by manufacturers of oatmeal and by stock feeders, for the hull is of little value to live stock except as it lightens the ration by increasing its bulk.

239. Methods of Improvement. Some improvement in the quality and yield of the crop may be obtained by cleaning and grading the seed grain, sowing only the heaviest and best seed. A considerable increase in yield will be obtained if this process is continued from year to year. The best and most reliable method for improving oats and developing new strains is to make selections of individual plants or heads, and to sow the seed from each of these individuals in separate rows. The best strains can then be selected and the seed threshed and sown at a uniform rate in rows of a given length the following year, so as to obtain a reliable test of their yielding power. Each strain should be threshed by itself and the yield recorded each year, the best strains then being sown on a larger scale the succeeding year. In this way, pure strains can be developed, either by straight selection or from plants produced by hybridization. The production of oat hybrids is rather a difficult process and is usually attempted only by professional plant breeders. Even the selection and testing of pure strains from commercial varieties involves too much detail to make it practical for the farmer.

240. Judging. Some of the agricultural colleges have devised score cards for the use of their classes in judging oats. While these differ in some minor points, they are usually based on the uniformity of the sample, the freedom from other grains, weed seeds, and dirt, the odor, the weight per bushel, and the percentage of hull to kernel. In some cases

the germination is taken into account. A good example of score cards of this kind is the one used by the College of Agriculture of the University of Wisconsin.

SCORE CARD FOR OATS

Trueness to type or breed characteristics	5 points
Uniformity in size and shape of kernels	10 points
Color of grain	5 points
Freedom from mixture with other grains	5 points
Size of kernel	10 points
Per cent and nature of weed seed, dirt, and other foreign material	15 points
Odor—musty, smutty, sulphur	15 points
Weight per bushel	10 points
Percentage of meat to hull	10 points
Viability	15 points
Total	100 points

LABORATORY AND FIELD EXERCISES

1. If material is available either from the field or from stored samples, write a complete description of the mature oat plant.

2. Each student should bring in a sample of threshed oats and carefully weigh out a portion of it. Then separate the whole grains from the weed seeds, chaff, and broken grains, and weigh each lot and figure the percentage of good seed. Now divide the whole grain into large and small kernels and figure the percentage of large, strong grains which the sample contains.

3. Take samples of the large and small grains and make a germination test. Study the differences in the growth of the two sets of plants carefully. It might be well also to grow small plats from large and small kernels on the experimental grounds, making careful note of any differences in vigor of growth.

4. Make up solutions of formaldehyde, mixing it with water in the proportions of 1 to 400, and 1 to 200. Figure how many gallons of water would be used to 1 pound (a pint) of formaldehyde at each of these rates. Treat small lots of seed for smut in each of the following ways:

(1.) No treatment.
(2.) Soak 15 minutes in the 1 to 400 solution.
(3.) Soak 15 minutes in the 1 to 200 solution.
(4.) Soak 30 minutes in the 1 to 400 solution.
(5.) Soak 30 minutes in the 1 to 200 solution.
(6.) Sprinkle till thoroughly wet with the 1 to 400 solution.
(7.) Sprinkle till thoroughly wet with the 1 to 200 solution.

In the soaking treatments, the seed should be stirred sufficiently so that it is all thoroughly wet. After it has been soaked the required time, it should be drained and dried. The seed which is sprinkled should be covered with a heavy cloth over night and dried the following day. A germination test should then be made of each sample. Some of them will probably show some injury from the treatment. If the seed is known to be infected with smut to some extent, it will be interesting to grow small lots from the different samples on the experimental grounds and determine the effectiveness of the different treatments.

5. Plant lots of oat grains in a box or in the open ground, covering them, 1, 2, 3, and 4 inches deep. Determine the percentage of germination at each of the different depths.

6. Let each student bring a sample of oats from home and score it according to the score card (Section 240) or, if preferred, the card used in your state agricultural college. Write the reasons for the markings given. If several samples can be scored by each student, so much the better. Check up each score carefully.

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CHAPTER VI

BARLEY

HISTORY AND DESCRIPTION

241. Origin and History. Barley belongs to the division of the grass family known as the *Genus hordeum*. It is among the oldest of cultivated plants, for it is mentioned in some of the earlier books of the Bible, and carvings on the ancient Egyptian tombs show heads of this grain. It was probably cultivated at as early a date as wheat, and much earlier than either oats or rye. As with many of our other cultivated plants, the exact place of origin and the original species are not now known. A wild form known as *Hordeum spontaneum*, which grows in Asia Minor, is regarded by some botanists as the original type, and it is very probable that the cultivation of this grain was begun in some portion of western Asia. The most common closely related species in this country is the wild barley or squirreltail grass, *Hordeum jubatum*, one of the worst weeds in meadows and pastures in the Northwestern prairie states. Barley was brought to Massachusetts and Virginia by the early colonists, and has since been generally cultivated in North America.

242. Botanical Characters. The cultivated varieties of barley are all grouped by botanists under a single species, *Hordeum sativum*. The plant makes a somewhat shorter growth than wheat or rye, though otherwise it is quite similar to those grains. The number of culms, or stems, which are produced varies with the thickness of the stand, but may be as high as 15 or 20 where the plants have plenty of room. The leaves are broader than those of the other grains, and

are of a grayish-green color. The head is similar to that of wheat, consisting of a spike with spikelets arranged along a central stem, or rachis. The spikelets are arranged in groups of three alternately at the joints of the rachis, making six rows of grain from the top to the bottom of the spike. The two-rowed appearance of some varieties of barley is due to the fact that only the central one of the three spikelets is fertile and produces grain. Many of the varieties are bearded, or awned; in some, the beard is replaced by a three-forked appendage, or hood. The grain is usually enclosed within the flowering glume, or hull, though some varieties thresh clean like wheat. It is either whitish or bluish black.

243. Classification. Varieties of barley may be divided into classes along several lines. The first general division into two-rowed and six-rowed forms is based on the fertility or infertility of the lateral spikelets, as stated in the preceding paragraph. Six-rowed barley is of two general forms, the round and the square, of which the square type is the more common. The former is the type usually known as six-rowed, while the square type is often spoken of as four-rowed. The four-rowed appearance is due to a twisting of the lateral spikelets, so that the grain at the left of one group of spikelets is in line with that on the right of the opposite one, the two rows appearing as one. Two types of two-rowed barley are also grown, one with a short, broad head and the other with a long, slender one; the latter is the common form. Another division may be made on the presence or absence of awns, or beards, the classes then being known as bearded and hooded, or beardless. Still other classes are the common, or hulled, and the naked, or hull-less, the division being made according to the manner in which the grain threshes from the head.

As with wheat, there are winter and spring forms. Winter barley is less hardy than winter wheat, but more so than winter oats. The winter varieties usually grown are of the

six-rowed bearded hulled type, though almost any variety will survive the winter in the milder portions of the South. The cultivation of winter barley is mostly confined to the

Figure 75.—Grains of six-rowed (on the left) and two-rowed (on the right) barley. The grains in the lateral spikelets of six-rowed barley are compressed as shown; there should be twice as many of these compressed grains as of fully developed ones in a sample of this type. Note that there are no compressed grains in the two-rowed barley.

Southern and Pacific states. Most of the barley sown in the spring in the Northern states is of the six-rowed bearded hulled type; in the irrigated states in the Rocky Mountain region the six-rowed bearded hull-less is grown. There are other types, however, which are less commonly grown, such

Figure 76.—Six-rowed bearded, two-rowed bearded, and six-rowed hooded barley.

as the hull-less six-rowed hooded, the hulled six-rowed hooded, the hulled and the hull-less two-rowed bearded, and the hulled two-rowed hooded.

244. Leading Varieties. The type which is generally grown in Wisconsin, Minnesota, Iowa, and the Dakotas, the area of largest production, is the common, or hulled six-rowed bearded, the most popular varieties being Manchuria and Oderbrucker. This type is also grown in New York and the other Eastern states. The most common varieties in California are the Bay Brewing and the California Feed. In the Rocky Mountain region, particularly at high altitudes, the hooded hull-less type is most prevalent, though some hooded hulled barley is grown. Varietal names in the hull-less barleys are largely based on the color of the grain as White Hull-less and Black Hull-less. This type of barley weighs 60 pounds to the bushel, while the legal weight of a bushel of hulled, or common, barley is established at only 48 pounds in most of the states.

IMPORTANCE OF THE CROP

245. World Production. The production of barley, like that of wheat and oats, is largely confined to the North Temperate zone. The total production of the world is about 1,500,000,000 bushels as compared with less than 4,000,000,000 bushels each of corn, wheat, and oats. The leading country in barley production normally is European Russia, with an average annual yield of 452,719,000 bushels for the five years from 1910 to 1914. This is nearly one third of the total production of the world. Other countries in which the production is large are the United States, with 186,000,000 bushels annually; Germany, 153,000,000 bushels; Austria-Hungary, 148,000,000 bushels; Japan, 94,000,000 bushels; Spain, 73,000,000 bushels; Great Britain and Ireland, 64,000,000 bushels; France, 47,000,000 bushels; and Canada, 44,000,000 bushels.

246. Production in the United States. Barley is ninth in value among our field crops, ranking below corn, hay, wheat, cotton, oats, potatoes, sugar, and tobacco. It is fourth among the cereals, following corn, wheat, and oats, and ranking above the grain sorghums, rice, and rye. The aver-

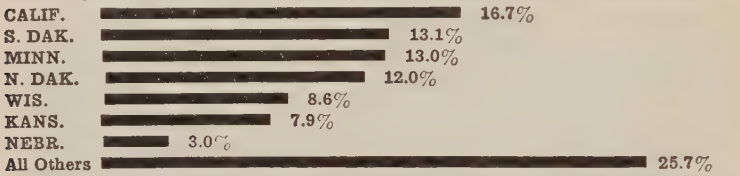

Figure 77.—Graph showing percentage of the total barley crop of the United States produced in the seven states of largest production in the five years from 1918 to 1922, inclusive.

age area devoted to barley in the United States during the five years from 1918 to 1922 was 7,773,000 acres. During this period the average acre yield was 23.9 bushels; the average annual production 186,846,000 bushels, and the average annual farm value, $142,158,000. The leading states in barley production are California, South Dakota, Minnesota, North Dakota, and Wisconsin. The average annual acreage, production and value in the seven states of largest production during the five years from 1918 to 1922 are shown in Table XI, while the proportion of the total crop of the United States produced in the more important states is shown graphically in Figure 77.

As shown in the table and the accompanying diagram, the greater portion of the barley crop is produced in California and the upper Mississippi Valley. In California, barley is most largely grown in the San Joaquin and Sacramento valleys. Southern Wisconsin, southern Minnesota, northern Iowa, eastern North and South Dakota, and northwestern Kansas are other sections of importance in the production of this crop. California produces more than one sixth of the barley of the entire country, while Minnesota, Wisconsin, and the Dakotas together grow considerably more than half of the entire crop. The highest acre yields are

obtained in the Rocky Mountain section, where much of the crop is irrigated, and in the Pacific Northwest. The average yield in Arizona for the five years from 1918 to 1922 was 33.6 bushels; in Utah, 31.2 bushels; and in Idaho, 31.0

Table XI. Average annual acreage, acre yield, production, and farm value of barley in the seven leading states during the five years from 1918 to 1922, inclusive.

State	Area	Acre yield	Production	Farm value December 1
	Acres	*Bushels*	*Bushels*	*Dollars*
California.....	1,179,000	26.6	31,257,000	29,130,000
South Dakota..	1,039,000	23.3	24,537,000	15,615,000
Minnesota.....	970,000	24.5	24,343,000	16,533,000
North Dakota..	1,202,000	18.4	22,396,000	13,316,000
Wisconsin.....	529,000	29.7	15,973,000	13,366,000
Kansas.....	736,000	20.1	14,703,000	8,234,000
Nebraska.....	251,000	22.8	5,586,000	3,505,000
All others.....	1,867,000	25.7	48,051,000	42,459,000
United States...	7,773,000	23.9	186,846,000	142,158,000

bushels. In comparison with these figures, the average yield to the acre in California was 26.6 bushels; in Minnesota, 24.5 bushels; and in Wisconsin, 29.7 bushels.

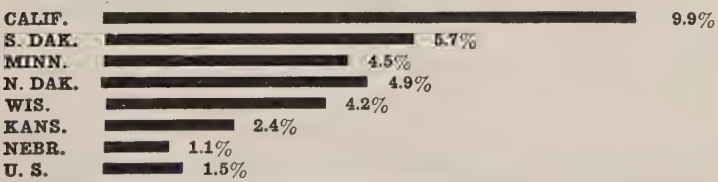

Figure 78.—Graph showing percentage of improved farm land sown to barley in the states of largest production and in the United States, 1918-1922.

Barley occupies a more important position in California than in any other state, 9.9 per cent of the improved farm land being sown to this crop, as shown in the accompanying diagram (Figure 78). It ranks next in importance in South Dakota, occupying about one eighteenth of the improved farm area, or nearly half as much as is sown annually to oats in that state. In Minnesota, the area sown to oats is about

four times as large as that sown to barley. Only 1.5 per cent of the entire farm area of the United States is devoted to barley, as compared with 20.3 per cent to corn, 12.8 per cent to wheat, and 8.5 per cent to oats.

Although some states may devote only one per cent of their improved farm land to the raising of barley, it will be noticed that the aggregate production and value of the same are, nevertheless, considerable and worth while.

THE PRODUCTION OF THE CROP

247. Soils Adapted to Barley Production. The best soil for barley is a well-drained loam. Good drainage and a reasonably fertile soil are essential to its successful growth. It does not ordinarily do well on heavy clays nor on light, sandy lands. It is extensively grown on soils of a volcanic origin in the Northwest. Barley grows better on alkali soils than any of the other small grains, and is sometimes used to reduce the quantity of soluble salts in the soil before sowing to oats, alfalfa, or some other crop which is less resistant to the injurious effects of these salts.

248. Fertilizers and Manures. The best fertilizer for barley is barnyard manure, particularly if this is applied to some previous crop or is well-rotted. Barley can be grown successfully on richer land than oats, but heavy fertilization is likely to cause a rank growth of straw with a tendency to lodge. As the roots of this crop do not penetrate as deeply as those of oats or wheat, the surface soil should contain an abundance of plant food. The yield of barley may be increased by the use of green manure crops, such as cowpeas, field peas, and the like, which add greatly to the vegetable matter in the soil, increasing the water-holding capacity and the supply of readily available plant food. On poor soils where neither barnyard nor green manures are available, beneficial results will be obtained from the use of commercial fertilizers. The many feeding roots which barley throws

out near the surface enable it to use commercial fertilizers quickly and to good advantage. The proper fertilizers to use depend largely on the soil to which they are applied. Phosphorus and potash are usually more necessary than nitrogen for the highest yields of barley.

Figure 79.—Barley grains; upper row, six-rowed hulled; center row, two-rowed hulled; lower row, hull-less or naked.

249. Preparation of the Land. A well-prepared seed bed is essential to the best growth of this crop. Fall plowing is desirable wherever possible, for fall-plowed land usually holds moisture better the following spring and can be put in shape for seeding at an earlier date than spring plowing. Sowing barley on land that has been disked and not plowed is fairly successful when a cultivated crop was grown on the land the previous year, but this method is not so generally followed as with oats, while the results which are obtained are not usually as good. For winter barley, plowing should

be done some weeks previous to seeding, in order to allow the ground to become thoroughly settled. Where winter barley follows cowpeas cut for hay, a good seed bed can be prepared by disking and harrowing without plowing. The essential thing is to have the surface soil fine and mellow and the subsoil firm.

250. Preparing the Seed for Sowing. Thorough grading and cleaning of the seed is particularly essential to success in barley culture. These precautions are more necessary with the six-rowed varieties than with the two-rowed, since the lateral grains of the six-rowed are often much smaller than the median ones and are not fully developed. Only the largest and plumpest seed should be sown, to obtain quick germination, strong growth, and an even stand. Evenness in ripening is necessary to produce market barley of uniform quality, and careful grading is a means toward this end. Freedom from weed seeds is also very desirable, for weeds in the crop retard its growth, make it more difficult to cure properly, and injure its market value.

The formaldehyde treatment recommended for the covered smut (bunt) of wheat and for oat smut (Section 196, c) is effective in controlling covered smut of barley. Loose smut of barley is not killed by formaldehyde, but can be kept in check by the hot water treatment decribed for the loose smut of wheat (Section 196, c).

251. Sowing the Seed. Barley is usually sown with the grain drill at the rate of from 6 to 8 pecks to the acre. In the drier sections, the best quantity to sow may be as low as 4 pecks. Broadcast seeding usually produces much lower yields than drilling, and is not to be recommended where it is possible to use the drill. Hull-less barley is sown at the rate of from 4 to 6 pecks to the acre. The usual date of seeding is slightly later than for oats, varying from the latter part of March and the first week of April in Kansas, through the second and third weeks of April in Iowa, Nebraska, and

Illinois, and extending to the last week of April and the first half of May in Wisconsin, Minnesota, and the Dakotas. Winter barley is usually sown in September or early October. The proper depth for seeding varies somewhat with the condition of the soil, but is about 2 or 3 inches.

252. Harrowing. Barley, like the other small grains, is seldom cultivated in any way. Beneficial results are sometimes obtained from cultivating drilled barley with the harrow or the weeder, running these tools parallel to the drill rows. This serves to break the crust which is likely to form on the surface, lessens evaporation, and helps to keep down weeds. Harrowing is especially beneficial in dry seasons or in sections of slight rainfall.

253. Irrigation. A large part of the barley produced in the Rocky Mountain states is irrigated. The number of irrigations and the depth of water to be applied varies with different soils and seasons; but best results are usually obtained from two irrigations, the first about the time the heads begin to show, and the second when the grain is filling. The total depth of water applied usually does not exceed 1 foot, though more may be necessary in sections where the rainfall is particularly deficient.

HARVESTING THE CROP

254. Cutting and Shocking. As the appearance of the grain largely governs the market value of barley, it should be carefully harvested and stored. The proper time to cut this crop is when the grain is in the hard dough stage. If cut earlier, the quality is injured by shrinking, while, if cut later, part of the crop will be lost from shattering. The usual method of cutting is with the binder, though the header and the combined harvester are sometimes used in the dry sections of the Pacific and Rocky Mountain states. After the bundles have dried out somewhat, they should be set up in good shocks and carefully capped to protect as much of

the grain as possible from injury by bad weather. Long shocks are somewhat preferable to round ones, as they allow better circulation of air. After the grain is cured in the shock, in ten days or two weeks after cutting, it should be stacked until threshing time. The harvesting of spring-sown barley begins in Kansas and other states similarly located about July 1, and is general in Wisconsin and Minnesota about August 1.

255. Threshing. Threshing barley from the shock is a risky method, for the grain is very likely to be injured by the weather before it is threshed. When grain of the best quality is wanted for market, it is advisable to stack and thresh the cap bundles separate from the remainder of the crop. The discolored grain in these bundles can then be used for feed or can be sold by itself without injuring the market value of the entire crop. In sections where there is no danger of rain during the harvest season, threshing from the shock is the common practice. Cracking the grain in the thresher should be guarded against, as cracked kernels lower the market value. Special care should be given to the work of separation in threshing, so as to remove as much of the dirt and weed seeds as possible.

256. Storing the Grain. Damp, musty bins should be avoided in storing barley, for odor and appearance are important factors in the market value of the grain. If the grain is damp when threshed or becomes damp in the bin, it should be shoveled over several times to dry it out. Where there is danger of injury from grain moths or other insects, tight bins which can be fumigated should be provided.

MARKETING AND RETURNS

257. Marketing and Market Grades. Much less of the barley crop goes to market than was the case before the enactment of prohibition legislation. The market grades of this grain are based very largely on color, uniformity, appear-

ance, and odor, and on the strength and uniformity of germination. Material differences in price are made between the grades, and the farmer is usually well paid for care in handling the grain from the time it is harvested till it is delivered to the elevator. According to the official classification, the market grades of barley are Nos. 1, 2, 3, and 4, No. 1 feed, and rejected. No. 1 barley "shall be sound, plump, bright, clean, and free from other grain, not scoured nor clipped, and shall weigh not less than 48 pounds to the measured bushel." The other grades are relatively lower in quality and weight per bushel. On the Pacific Coast there are four special classes, with grades of Nos. 1, 2, and 3 in each, based on the variety of which the sample is composed, either wholly or in part. These are Bay Brewing and Bay Brewing mixed, Chevalier and Chevalier mixed.

258. Exports and Imports. The average exports of barley from the United States for the five years from 1916 to 1920 were 22,030,000 bushels out of a crop slightly over 200,000,000 bushels. The exports went to England, Australia, and other countries, for the production of malt and for other uses.

259. Prices and Acre Value. The average farm price of barley on December 1 for the entire United States for the ten years from 1913 to 1922 was 74 cents. In California, the state of largest production, it was 92 cents, while in Minnesota and North Dakota, which rank next in order of production, the average prices per bushel were only 70 and 63 cents, respectively. The high price in California is due largely to the scarcity of other grain, while the lower price in the other states mentioned is due to the plentiful supply of wheat and oats which is there produced.

The average value of the grain from an acre of barley for the five years from 1915 to 1922 was \$18.08 for the entire United States. For California, \$25.03 was the acre value; for Minnesota, \$17.50; and for North Dakota, \$10.53. The

highest acre value is that recorded for Nevada, and the lowest, that for North Dakota. In general, the higher acre values are found in the New England, Rocky Mountain, and Pacific states, and the lower in the Central and Southern states.

260. Cost of Production. The reports of about two hundred correspondents of the Bureau of Crop Estimates as reported in the Crop Reporter for October, 1911, show that the average cost of producing an acre of barley in 1909 in the United States was $10.05, divided as follows: preparing ground, $1.84; seed, $1.14; sowing, 46 cents; harvesting, $1.28; preparing for market, $1.50; rental value of land, $3.17; other items, 66 cents. As the average value of an acre of barley that year was $12.15, the crop shows a net return of $2.10 an acre for the grain alone. In California, the average cost was $10.46, with a value of $16.35; Minnesota, $9.43, value $10.43; and Wisconsin, $12.49, value $15.18. The cost of a bushel of grain averaged 36.4 cents for the entire United States. Recent data show an acre cost of $15.73 in North Dakota in 1917, or 72 cents a bushel. On irrigated land in Colorado the acre cost ran over $40.00.

RELATION TO OTHER CROPS

261. Place in the Rotation. In the Mississippi Valley states, barley occupies about the same place in the rotation as oats; that is, it usually follows corn and precedes the grass crop. As with other grain crops, the heaviest yields are usually obtained when barley is grown after corn, potatoes, or some other cultivated crop. Excellent results are also obtained when it follows a leguminous crop, such as field peas in the North and cowpeas in the South. Barley yields better after corn than after oats, when these three crops are grown in a rotation.

262. Use as a Nurse and Smother Crop. On account of its early maturity and the fact that it draws rather lightly

on the soil moisture, barley is an excellent nurse crop to use when seeding down to grass or clover. Its early maturity also makes it of value in clearing weedy land, since it can be cut before many weeds mature their seeds. It is of less value as a smother crop than oats, as it makes less shade.

263. Sowing with Other Grains. As noted elsewhere (Section 232), barley and oats are frequently sown together for the production of feed grain. The largest yields are obtained when about 1 bushel of each grain is sown to the acre, using a medium late variety of barley and an early variety of oats, so that the two grains will ripen together. The yields from these grain mixtures, which are quite commonly grown in Ontario and other portions of Canada and to a lesser extent in the northern United States, are larger than those from either crop when sown alone.

THE USES OF BARLEY

264. The Manufacture of Malt. Before the passage of prohibition legislation about one fourth of the barley crop of the United States was used in the manufacture of malt for the production of beer and other malt liquors. Malt is produced by extracting the starch from the grain after it has been changed in form by the germination process, the grain being placed in vats or tanks where it is moistened and heated sufficiently to induce rapid germination. Considerable barley is still used for malting, for the production of near beers and malt extracts. Brewing, or malting, barley should be clean and bright in color, free from other grains, weed seeds, and broken grains, and of high germinating power. Broken grains or those which will not germinate are objectionable, because they mold in the germinating tanks and the mold is communicated to the healthy grains.

265. Feeding to Stock. Barley, either whole or ground into meal, is quite largely used for feeding to stock. In the Mississippi Valley it is most largely used for feeding to hogs,

as it produces pork of very high quality. It is also useful for fattening sheep and for feeding to dairy cows and poultry. It is not often fed to horses in this section, but in the Pacific states it is a standard feed for this class of animals. The feeding value of barley is about the same as that of corn.

266. Use as Human Food. This grain is normally little used as human food in the United States, though in some portions of Europe it is commonly made into bread. In America, it is principally used as pearl barley for soups and as a cereal breakfast food. Pearl barley is the kernel from which the hull has been removed. During war conditions and the need for conserving wheat, barley flour has been extensively used as a wheat substitute.

267. Use of the By-Products. Barley straw, the by-product of grain production, is generally fed to animals or used as bedding. As most of the barley which is produced in this country is bearded and these beards cannot be separated from the straw, barley straw is less palatable than that of oats or beardless wheat. It is also less nutritious than wheat straw. As bedding, it is said to be slightly better as an absorbent of liquids than oat straw. It is also a little higher in fertilizing value than oat straw.

The by-products of the malting industry, malt sprouts and brewers' grains, are largely used for stock feed in the vicinity of malt houses, either in the wet or the dried state. The dried sprouts and brewers' grains are more pleasant to handle, and are generally better for feeding. Malt sprouts are the sprouts produced during germination, which are broken off before the soluble starch compounds are extracted. They are high in protein and are a very good feed, particularly for dairy cows. Brewers' grains are the barley or other grains from which the soluble starch has been extracted. Since they contain much of the protein of the original grain, they are high in feeding value. Like malt sprouts, they are largely fed to dairy cows. Both these feeds

can usually be purchased at reasonable prices, and can be used with profit where they are readily obtainable.

268. Barley for Hay and Pasture. Barley is not often used as a hay crop except in the West and South. The bearded kinds should be cut while the beards are still soft, or they will cause injury to the mouths of animals to which the hay is fed. The beardless varieties are to be preferred for hay production in the region to which they are adapted. Beardless barley is now being grown to some extent in the South as a hay and pasture crop, though conditions are not favorable for the production of grain. Barley hay is high in feeding value, and, if cut at the right stage, is relished by stock. Winter barley makes excellent pasture for stock of all kinds both in the fall and the spring within the region to which it is adapted. Spring barley also produces nutritious early spring pasture, and is sometimes sown for this purpose, particularly for hogs and sheep.

INSECTS AND DISEASES

269. Insect Enemies. The insects which are most troublesome in growing barley are the chinch bug, Hessian fly, and spring grain aphis. See Sections 196 and 228.

The most destructive insects in stored barley are the grain weevil and the Angoumois grain moth. The most effective way of preventing damage from weevils and moths is to store the grain in tight bins and fumigate occasionally with carbon bisulphide.

270. Diseases. The most injurious diseases of barley are the rusts and smuts. The two kinds of rust and two kinds of smut on barley are quite similar to the corresponding diseases on wheat. Covered smut may be destroyed by treating with the formaldehyde solution and loose smut by the hot water treatment (Section 195). These diseases are frequently quite destructive, and the annual production of barley is materially decreased by loss from smut.

Stem rust also does considerable damage, particularly in seasons favorable to its development. The sowing of early varieties which ripen before rust ordinarily becomes prevalent, and the use of well-drained land for producing this crop are recommended as preventives of rust injury. The stripe disease has also materially reduced the yields of this crop in Wisconsin and in Minnesota.

Figure 77—Smutted heads of barley. The three upper ones, covered smut; the two lower, loose smut.

IMPROVEMENT OF THE CROP

271. Opportunities for Improvement. Barley can be improved by increasing the yield, by increasing the size and plumpness of the individual grains, and in other ways. For malting, a low protein content and a high proportion of starch are desired; while for feeding a high protein content is wanted. It is possible to produce strains by selection which are relatively high or low in protein, but this requires much careful work and can hardly be undertaken except by professional plant breeders.

272. Methods of Improvement. The methods of improving barley are not different from those practiced with wheat (Section 198) and oats (Section 239). Grading the grain

and sowing only the heaviest and plumpest kernels will eventually improve the yield and quality of the crop. The selection of good heads from the field, using the seeds from them to sow a seed plat from which all plants not of uniform type are removed before harvest, and increasing this seed until enough is produced to plant the main crop, will materially improve the quality, yield, and uniformity of the crop. New varieties may be produced by the selection of specially good individual plants and by hybridization.

273. Judging. The excellence of a sample of barley is determined largely on its uniformity, its freedom from broken grains, weed seeds and other foreign matter, its condition, and its weight per bushel. Germination is also a factor which is usually considered.

The following score card is used by the College of Agriculture of the University of Nebraska:

SCORE CARD FOR BARLEY

Uniformity	
Color	20 points
Texture	20 points
Size	10 points
Quality	
Weight per bushel	15 points
Injury in threshing	10 points
Sprouted, bin-burnt, decayed, etc	15 points
Foreign matter	10 points
Total	100 points

LABORATORY AND FIELD EXERCISES

1. Have each student make a study of the barley plant and write a description of it. If several widely different varieties can be used for this work, and their differences and similarities brought out, the value of the study will be greatly increased.

2. Make studies of samples of thrashed barley to determine whether they are two-rowed or six-rowed. The six-rowed samples will contain approximately twice as many compressed or twisted grains as fully developed ones, due to the manner in which the lateral grains in the spikelets press against one another (See Figure 71). Pure samples of two-

rowed barley will contain none of these compressed grains. Mix together lots of two-rowed and six-rowed barley which are similar in appearance and let the class determine about what proportion of each was used in the mixture.

3. Make germination tests of samples of barley. If desired, the strength of germination of the medium and lateral grains of six-rowed barley may be compared.

4. Examine samples of barley and determine what percentage is pure grain and what trash and weed seeds.

5. Test planting at different depths, noting differences in germination and growth.

6. Devote considerable time to practice in scoring and judging samples of barley.

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Farmers' Bulletins:
968. Cultivation and Use of Barley.
Department Bulletins:
622. Identification of Varieties of Barley.

CHAPTER VII

RYE

274. Origin. Rye has been cultivated only in comparatively recent times, for it was not known among the Greeks and Romans. It probably grew originally in western Asia and southeastern Europe, as several species of wild rye, any one of which may be the parent of the cultivated type, are still found there.

275. Description. Rye is quite closely related to wheat, and its manner of growth is much the same. The straw is longer and more wiry, and the heads are more slender and are always bearded. Unlike wheat and the other small grains, rye cross-fertilizes freely, which fact is probably the reason why so few distinct varieties have been developed. It is a comparatively easy matter to maintain a pure stock of wheat, oats, or barley and so to develop in time a new variety from any particularly good plant. There is little danger of mixing the varieties of these grains if proper care is used in sowing, harvesting, and threshing. Rye, however, may become mixed in the field by pollen carried from other plants by the wind or by insects, and hence it is quite difficult to build up a pure strain. Only a few varieties are recognized even by seedsmen, and farmers ordinarily grow simply "winter rye" or "spring rye." Most of the rye grown in this country is sown in the fall, for winter rye is our hardiest winter grain and there are few localities where it does not succeed.

276. Importance of the Crop. The world production of rye is greater than that of barley, but less than that of wheat, corn, oats or rice. Before the World War, nearly half of the world's crop of 1,750,000,000 bushels was grown in European Russia, and about one quarter in Germany. In these coun-

tries and in Sweden and Norway, rye is ground into flour and made into bread. In fact, rye bread is one of the principal articles of diet there, particularly among the poorer classes. Other countries where large quantities of rye are grown are Austria-Hungary, with an average annual production of 161,000,000 bushels in the five years from 1910 to 1914, and France with 48,000,000 bushels. The average production of the United States in this period was 37,368,000 bushels.

Figure 81.—Typical heads of rye.

277. Production in the United States. Rye is exceeded in value by eleven of our field crops, ranking next above rice. The average area devoted to the production of rye during the five years from 1918 to 1922 was 5,569,000 acres, with a mean yield of 13.8 bushels to the acre and a total average production of 76,817,000 bushels, valued at $84,881,000. Table XII shows the leading states in the production of rye, with the 5-year average acreage and production in each.

Table XII and Figure 82 show that the most of the rye crop is produced in a few states, the first three mentioned producing nearly half of the average crop. The remainder

of the production is scattered over a large number of states, mostly northern. The development of rye production on a large scale in North and South Dakota, particularly the former, began in 1915. The average area devoted to rye in North Dakota during the ten years from 1908 to 1917 was only 197,000 acres, while 1,900,000 acres were harvested in

Table XII. Average annual acreage, acre yield, production, and farm value of rye in the six leading states during the five years from 1918 to 1922, inclusive.

State	Area	Acre yield	Production	Farm value December 1
	Acres	*Bushels*	*Bushels*	*Dollars*
North Dakota..	1,484,000	11.0	16,144,000	16,174,000
Minnesota.....	661,000	17.7	11,799,000	11,304,000
Michigan.....	675,000	13.6	9,164,000	10,263,000
Wisconsin.....	425,000	15.5	6,616,000	7,539,000
South Dakota..	345,000	15.7	5,637,000	5,820,000
Indiana.....	324,000	13.9	4,544,000	5,461,000
All others.....	1,655,000	13.8	22,913,000	28,320,000
United States...	5,569,000	13.8	76,817,000	84,881,000

1918 and 2,037,000 acres in 1919. In 1920 and 1921, the area decreased to less than a million acres annually, but in 1922, 1,581,000 acres were harvested. This large acreage of rye in North Dakota is due in part to the increased demand for rye for export in recent years, but largely to the fact that it requires little labor and can be sold in the fall, while all other crops in the state must be sown in the spring. Although the acreage of rye in South Dakota is much smaller than that in North Dakota, yet the average acreage in the five years from 1918 to 1922 was four times that in the preceding ten years. Before 1917, Wisconsin, Michigan, and Pennsylvania were the most important rye-producing states.

The highest average acre yield of rye is that in Connecticut, 19.8 bushels. Massachusetts follows closely with 19 bushels. Of the states where a large acreage of rye is grown, the highest yields are obtained in Minnesota, with

an average of 17.7 bushels. The highest value to the acre is reported in New England and the lowest in the South, where yields are low. The acre value (5-year average) in North Dakota is $10.90; in Minnesota, $17.10; and in Michigan, $15.20.

Comparative acre yields in foreign countries previous to the World War were approximately 12 bushels in Russia, 25 bushels in Germany, and 20 bushels for Austria-Hungary.

278. Growing the Crop. Rye will grow on rather poorer soils than the other cereals, and is frequently planted on land which is low in fertility or which is not in good condition to produce crops, such as that which is just being brought

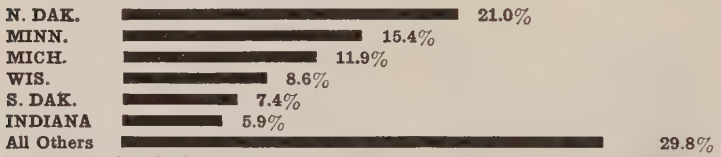

Figure 82.—Graph showing the percentage of the rye crop of the United States annually produced in the six states of largest production, 1918-1922.

into cultivation. Materially increased yields are obtained by growing this crop on good soil and in a well-prepared seed bed. The best yields are obtained from loam soils which are quite fertile. The seed bed for winter rye should be prepared by plowing some time previous to sowing, as early as August 1, if it is possible to remove the previous crop by that time. The land should then be disked and harrowed to make it fine and mellow, and to prevent drying out. It should be harrowed often enough during the interval between plowing and seeding to prevent the growth of weeds. Sowing with the grain drill is preferable to broadcast seeding. The usual rate of seeding is from 5 to 6 pecks to the acre, though as much as 8 pecks may be sown when winter pasture is desired.

The time of seeding depends on the locality and the use which is to be made of the crop. If intended for fall pasture, the seed may be sown early in August in the Northern states,

or during the latter part of August or early in September farther south. If grown for grain alone, September is the usual month for seeding in the North, and October in the South. Winter rye may be sown later than winter wheat, and is not usually sown until after wheat seeding is finished.

Figure 83.—A field of rye ready for harvest.

The methods of harvesting and threshing are not different from those in use with the other grains.

279. Uses of the Rye Grain. In the United States, only a small portion of the rye crop is normally used as human food. In some European countries, however, it is largely used as a wheat substitute. The grain is usually ground into flour and made into bread, though a few cereal breakfast foods are made wholly or in part from this grain. In the form of pearl barley it is often used in soups. In Russia and various portions of northern Europe, rye bread is one of the chief foods of the people. The bread made from rye flour is close in texture and dark in color. Previous to the adoption of prohibition legislation, about one third of the

rye crop in America was used in the manufacture of alcohol and alcoholic beverages. A large part of the crop, in recent years half or more than half, is exported. The grain is excellent for feeding to stock, though best results are usually obtained when rye is fed in combination with other grains. The best use of the grain can be made when it is fed to horses or hogs. For feeding to hogs it should be combined with barley, corn, or shorts, while it is best for horses when fed with oats.

280. Uses of the Green Plant. The green plant is an important item of stock food, both as late fall and early spring pasture and as a crop for green feed. Rye which is sown in August or early in September will furnish considerable pasturage during the fall months, and can be pastured quite closely without danger of winterkilling. The plants from this early sowing should be pastured closely enough to prevent the formation of heads in the fall. Rye also furnishes excellent pasture in early spring, and may be pastured for two or three weeks at that time without seriously reducing the yield of grain. For feeding green to stock, the plants should be cut about the time they come into head, as the straw becomes stiff and wiry and is unpalatable if allowed to become more mature.

Rye is frequently plowed under as green manure to add humus to the land. It makes a quick growth in the spring and produces a large quantity of material early enough so that it can be plowed down and another crop grown on the land the same season. In the South, rye makes a good winter cover, as it may be sown later than most other crops, it never winterkills, and it begins to grow as soon as the first warm days come. While it is excellent to prevent the soil from washing, it adds little to the fertility of the land and is of much less value as a green manure crop than any of the legumes. If sown with winter vetch or field peas, it provides a support and increases the supply of vegetable matter.

281. Uses of the Straw. Rye straw is of little value for feeding, but its stiff, wiry texture, which makes it distasteful to stock, makes it useful for various other purposes. It is used in the manufacture of coarse straw articles, such as cheap straw hats, strawboard, and paper, and for the stuffing of horse collars. For the latter purpose, the grain is flailed out to prevent the straw from being broken, or is threshed with special machines which keep the straw straight. Rye straw is also much in favor as packing material for trees and other nursery stock, and as bedding for live stock. Breeders of fancy horses and of exhibition stock of other kinds often pay extra prices for rye straw for bedding. In eastern markets rye straw is sometimes quoted as high as second grade timothy and almost as high as the grain.

282. Diseases and Insect Enemies. The most common disease of rye is ergot, in which the grains are replaced by long black or purplish masses of spores. This disease occurs on many of the wild and cultivated grasses and occasionally on the other small grains, but of our cultivated crops it is most frequent on rye. The spores of this parasite enter the ovule when it begins to develop and the growth of the fungus gradually replaces that of the ovule. By the time the grain matures, the spore-mass of ergot has developed into a hard, elongated, slightly curved body from one half to one and one half inches long. The fungus reduces the yield of grain to some extent, but it is most serious when it occurs in considerable quantity and causes poisoning and other serious disorders of stock which eat it. Ergot is used to some extent in medicine. The best preventive measures are thorough cleaning of the seed and rotation of crops so as to avoid sowing rye on the same land two years in succession. No other disease of rye is serious, though both black and brown rust sometimes occur. This crop is less seriously affected by insect pests than wheat and preventive measures against insect attacks are seldom necessary.

LABORATORY AND FIELD EXERCISES

1. Make a study and write a description of the rye plant, as has already been done with the other cereals.

2. If it is possible to obtain several samples, have them judged and placed according to their relative value.

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CHAPTER VIII

FLAX

HISTORY AND DESCRIPTION

283. Origin and History. Flax, like wheat, has been grown from the earliest times of which we have records. Its earlier cultivation was for the production of fiber, the manufacture of cloth (linen) from flax fiber being an art which was practiced by the ancient Egyptians and Hindus. The use of the seed for the manufacture of oil and for feeding to stock seems to have been of comparatively recent development. Flax still grows wild in the region around the Black Sea, in what is now Asiatic Turkey. While it is quite possible that this is the region from which it was originally obtained, this plant is so likely to run wild in localities where it is cultivated, and to maintain itself in the wild state for years, that it is equally possible that it may have been brought to the Black Sea region from some other country. In fact, flax is quite frequently found growing wild in the United States, though it is well known that it is not native. The cultivation of flax was carried from Egypt and western Asia into Europe, and from Europe it was introduced at an early date into America. The ancient peoples of central Europe cultivated a perennial species, but this was later replaced by the annual species from western Asia.

284. Botanical Characters and Relationships. Flax belongs to the *Linaceae*, or flax family, the typical genus and the only one which grows in the northern part of the United States being *Linum*, to which the cultivated flax belongs. The only species of this genus which is cultivated in the United States is *Linum usitatissimum*, though two other

species are occasionally cultivated in other parts of the world and a number of species grow wild in America and elsewhere.

Our common flax is an annual, with a single upright stem and a long taproot with few small branches. The number of the basal branches and the length of the fruiting branches of the stem depend largely on the thickness of seeding. Plants

Figure 84.—Field of flax in bloom.

which have plenty of room to develop will produce numerous branches, while those that are crowded branch little or not at all, except for the branches of the panicle. The flax plant grows from 12 to 36 inches high, the length of straw depending on the variety, the soil, and the season. The leaves are alternate, lanceolate, from one half to one and one half inches long. The flowers are produced in a leafy terminal panicle; the flower parts are in fives, the flowers themselves being about a half inch across and usually of a light blue color. The rounded capsules contain eight or ten seeds, which are usually light brown in color; they are flattened and have a smooth, shining or polished surface.

The stems of flax are made up of three layers, the bark, the wood, and the pith. The bark is composed of several layers, of which the most important from an economic point of view is the bast, or fiber, cells. These cells are only about one tenth to one sixth of an inch long, but are so firmly fastened together that fibers of the entire length of the straw may be removed. The process of separating these fibers from the other portions of the stem is described elsewhere. (Section 292).

IMPORTANCE OF THE CROP

285. World Production. There are few plants which are put to a greater variety of uses than flax. The fiber from the stem is used in the manufacture of many articles, from the finest linen cloth to coarse twine and bagging. The oil from the seeds is used in the manufacture of paint, varnishes, and other articles; the grain from which the oil has been removed is fed to stock. The mucilage-like substance which exudes from the seed coat when the grain is dampened is made use of to some extent in medicine, in the making of poultices and for other purposes. The greater portion of the flax which is grown in this country is produced for the seed, from which oil and oilmeal are manufactured, though the straw is used to some extent in the manufacture of twine, bagging, and upholstered articles.

Fiber flax is produced largely in Russia and in Austria-Hungary, Russia normally furnishing nearly four fifths of the world's supply. Argentina is the leading country in the production of seed flax, the United States and Russia ranking next in importance. Argentina produced more than 29 per cent of the entire world's crop of flaxseed in the five years from 1909 to 1913; European Russia, slightly less than 20 per cent; British India, 18 per cent; and the United States, slightly less than 18 per cent. The average world production for this period was 109,000,000 bushels.

286. Production in the United States. In the five years from 1918 to 1922, as shown in Table XIII, more than two fifths of the flax crop of the United States was produced in North Dakota, the average area in that state being 643,000 acres, and the average production 4,304,000 bushels. Minnesota and South Dakota produced nearly half of the crop, most of the remainder being grown in Montana. Figure 85 shows the portion of the crop produced in the four leading states. While the production of flax is more im-

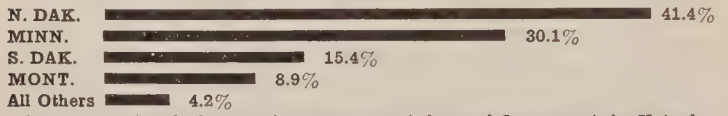

Figure 85.—Graph showing the percentage of the total flax crop of the United States produced in the four leading states, and all others, 1908-1917.

portant in North Dakota than in any other state, the acreage there and in the other principal flax-growing states has declined greatly in recent years. The average annual production in the United States is about ten and a half million bushels. In annual value, the flax crop of the United States ranks far below rye and rice, the average being only $25,842 in the five years from 1918 to 1922.

The standard weight of a bushel of flax is 56 pounds.

GROWING THE CROP

287. Soils Adapted to Flax. In America, flax is grown almost entirely in newly settled districts, and is quite generally the first crop sown after the breaking of prairie sod. There are two reasons for this practice. One is that flax grows better than almost any other crop on tough sod and it is effective in subduing new land; the other is that when flax is grown for several years in succession, the land becomes "flax sick" and fails to produce a profitable crop. The condition known as flax sickness is explained elsewhere (Section 295). The crop grows best in a rather cool climate and on soils that are not too heavy. Sandy loams are better adapted to flax than are clay loams or heavy clays. The idea is very

common among farmers that flax is "hard on the land," but the failure of the crop when it is grown for several successive years on the same field is due more to diseases than to the removal of soil fertility. The general practice of growing flax only on new land makes the use of fertilizers and manures practically unnecessary.

Table XIII. Average annual acreage, acre yield, production, and farm value of the flaxseed crop in the United States and in the four leading states during the five years from 1918 to 1922, inclusive.

State	Area	Acre yield	Production	Farm Value December 1
	Acres	*Bushels*	*Bushels*	*Dollars*
North Dakota	643,000	6.7	4,304,000	11,516,000
Minnesota	328,000	9.5	3,127,000	8,119,000
South Dakota	188,000	8.5	1,597,000	3,732,000
Montana	312,000	3.8	924,000	2,407,000
All others	46,000	9.5	435,000	992,000
United States	1,517,000	6.9	10,387,000	26,766,000

288. Preparation of the Land. The usual method of preparing sod land for flax is to flat break it in the fall or early in the spring, running the plow just deep enough to turn the sod over. It may be cut up with the disk harrow in the spring if the breaking was done the preceding summer or fall, setting the disks quite straight to avoid turning up the unrotted turf. The use of the roller or some other implement for packing the soil is advisable on newly plowed land. The seed is sometimes sown on new breaking with little or no preparation, but the increased yields which are obtained where a good seed bed has been prepared usually pay for the extra work. On old land, deep plowing and thorough preparation are necessary in order to get the best results. A firm, well-packed seed bed is more essential to success with flax than with almost any other crop.

289. Preparing the Seed for Sowing. Thorough cleaning and grading of the seed are necessary to obtain the best

yields. All light seed, straw, dirt, and weed seed should be removed by running the grain through the fanning mill several times. By grading, seeds of uniform size and weight are obtained, all of which contain practically the same quantity of food material for the young plants. If proper care is taken in sowing to cover the seed to a uniform depth, the growth of the crop throughout the season is uniform, and it all ripens at the same time, an important consideration. After the seed has been cleaned and graded, it should be treated with the formaldehyde solution recommended for wheat smut (Section 196, c). This destroys any spores of the flax wilt fungus which may adhere to the seed, and seems also to be of actual benefit to the early growth of the plants. The best method of treatment is to sprinkle the solution on a pile containing from 5 to 10 bushels of seed, shoveling it over so that it is all reached by the fungicide. About one half gallon of the solution is needed for each bushel of seed. After all the seed is moistened, cover the pile with a canvas or blanket for a couple of hours and shovel the seed over once or twice during the first hour after treating. The seed may be sown with the grain drill after it has been treated.

290. Sowing the Seed. The usual method of sowing flax is with the grain drill, the type with press wheels being rather better than any other, as it helps to supply the firm seed bed so necessary for the best growth of this crop. The usual depth of seeding is from ½ to 1 inch. In the United States the common rate of seeding is from 2 to 3 pecks to the acre. This seeding produces plants with numerous branches, and encourages the production of large yields of seed. On the other hand, thick seeding produces single stems, long straight fiber, and comparatively few seeds. When flax is grown for fiber, the rate of seeding should be greatly increased. The quantity of seed sown for fiber production in Europe is 2 bushels or more to the acre. The young plants are quite easily injured by late spring frosts, hence seeding should be

delayed until danger from them is practically past. On the other hand, seeding at the earliest safe date is desirable in order to escape the early fall frosts. Flax is usually sown in the latter half of May and harvested early in September, the growing season of the crop being from 90 to 100 days.

HARVESTING AND HANDLING.

291. Harvesting the Crop. The usual method of harvesting seed flax is with the grain binder. The crop cures readily in the shock and is not easily injured by the weather, though excessive rains will reduce the value of the seed. The seed is removed from the straw with the ordinary threshing machine. The harvesting of fiber flax is quite another matter, as practically all the work must be done by hand to insure fiber of the best quality. Various machines have been devised for the harvesting and later handling of fiber flax, but they have not been entirely satisfactory. The large amount of hand labor required in the production of this crop accounts for its failure to find favor with American farmers. For the profitable production of fiber flax, an abundance of cheap labor is necessary. The plants are pulled by hand and tied into small bundles, and are then put into shocks for curing. Cutting them off by machinery permits weathering and contact with the soil which injure the fiber at the cut ends.

292. The Handling of Fiber Flax. While the production of flax for fiber may never become important in America, the various steps in its handling are of interest. The seed is threshed out of the bundle after it has cured for two or three weeks in the shock, either by rubbing or by holding the heads between revolving rollers while the straw is held in the hands. The straw is then bound into bundles for the next process, which is known as retting. This is the preparation of the straw for the removal of the outer layers from the stalk, by spreading it thinly on the ground and exposing it to

the weather for three or four weeks. After this time, the various layers separate easily and the wood and bark are removed by a process known as breaking. The straw is either pounded with wooden mallets or bent in some sort of machine, but the best quality of fiber is obtained when the

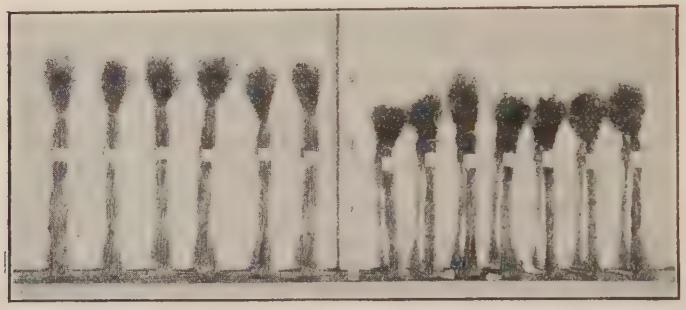

Figure 86.—Samples of flax: at the left, the fiber type; at the right, flax grown for seed production.

work is done by hand with mallets. Any coarse fiber, bark, or wood which remains is removed by a process known as scutching, which consists of beating the bundles of fiber with a series of paddles. This is sometimes done by hand, but usually by machinery. The fiber is then sorted according to its quality and baled into bundles of about 200 pounds each. It is kept in these bales until it is spun into thread and woven into cloth, either alone or in combination with cotton. Some of the finest laces and fabrics are made from linen thread. The coarser fiber, or tow, is used in the manufacture of twine and in upholstering.

MARKET AND RETURNS

293. Market Grades of Flaxseed. Minneapolis is one of the principal markets for flaxseed, and the official grades fixed by the Minneapolis Board of Grain Appeals may be taken as standard. These grades are No. 1 Northwestern, No. 1, No. 2, and No grade. No. 1 Northwestern flaxseed

"shall be mature, sound, dry, and sweet. It shall be northern grown. The maximum quantity of field, stack, storage, or other damaged seed intermixed shall not exceed 12½ per cent. The minimum weight shall be 51 pounds to the measured bushel, commercially pure seed." No. 1 flaxseed may contain 25 per cent of immature or damaged seed, and weigh not less than 50 pounds to the bushel. The other grades include flax not fit for either of the higher grades.

294. Prices and Acre Value. The average farm price of flaxseed in the United States for the five years from 1918 to 1922 was $2.554 per bushel, with a range from $1.451 in 1918 to $4.383 in 1922. The flax crops of the United States since 1913 have been all small, while that of 1919 was the smallest in many years. This small crop, combined with the high prices of all other grains and the difficulty of obtaining cargo space for flax shipments from Argentina, caused flax prices to reach the highest point ever known. The price which can ordinarily be expected for flaxseed varies from $1.25 to $2.00 per bushel. At present, the Minneapolis price for flax is around $3.00 per bushel. The average acre value usually ranges from $10 to $12, though in recent years it has been slightly higher. This is for the seed alone. Where there is a demand for the straw, this brings in some additional return. As flax is ordinarily grown with very little expense, there is a reasonable profit in the crop.

DISEASES AND INSECT ENEMIES

295. Diseases and Insect Enemies. The principal disease which attacks flax in this country is flax wilt. It is this disease which commonly causes the condition known as "flax-sick soil," though other fungous diseases produce the same result. Flax wilt is a fungus which enters the young plant, from spores either in the soil or on the seed. The fungus grows inside the tissues of the plant and fills the cells, causing the plant to die as if from lack of water. The

plants are attacked at all stages of growth, from young seedlings to maturity. The best preventive measures are to sow only clean seed from which all dirt and pieces of flax straw have been removed, to treat the seed with the formaldehyde solution (Section 195), and to grow flax on new land only, or as a single crop in a rotation of several years' duration. Much can also be accomplished by saving seed from plants which mature in flax-sick soil and hence are resistant to the disease. Manure containing flax straw or from stock fed on flax straw should not be put on land on which flax is to be grown. Several other fungous diseases occur, mostly similar to flax wilt, though less serious, and yield to the same treatment. Fortunately the crop is not very subject to serious injury from insects.

ROTATION, USES, IMPROVEMENT

296. Place in the Rotation. On account of the fungous diseases which attack flax when it is grown for several years on the same land, rotation of crops is particularly essential if this crop is to become a permanent one in any locality. On account of the common practice of growing it only on new land, no definite rotations containing flax have yet been established. To escape injury from flax diseases, this crop should not be grown on the same field more frequently than once in five years, and better results are obtained where a cultivated crop and a grass crop are included in the rotation than where small grains alone are grown.

297. Uses of Flaxseed. Practically all the flaxseed produced in the United States is utilized in the manufacture of linseed oil. There are two methods of extracting the oil from the seed, known as the old process and the new process. The old process consists of crushing the seed, heating it to about 165 degrees F., and placing it in sacks or between cloths and forcing the oil out by pressure. The new process differs from this in that the crushed and heated seed is placed

in tanks or cylinders and treated with naphtha to extract the oil. This oil is then used in the manufacture of paints, varnishes, oilcloth or linoleum (in combination with ground cork), and various other articles. The meal from which the oil has been extracted is used for feeding to stock, either as it comes from the presses as oilcake, or crushed or ground

Figure 87.—A linseed oil mill, with steel tanks at the right for storing the flaxseed.

into the form known as oilmeal or linseed meal. Oilmeal is very rich in protein, and is used for feeding to dairy cows and to other animals. On account of its richness, it must be fed in small quantities, in combination with other grains. Whole flaxseed is seldom fed to stock, for it is too high in price as compared with other grains. Flax straw in not usually regarded as a feeding stuff of value, though it contains considerable nutriment. In years when other forage is scarce, however, it is quite a useful feed. The straw is now utilized to some extent in this country in the manufacture of twine, coarse bagging, tow for upholstering, and felting material.

298. Improvement of the Crop. While the growing of fiber flax may never become an important industry in the United States, more attention can well be given to the pro-

duction of better grades of straw for the mills which utilize it in the manufacture of twine and other articles. The farmer thus gets a double return for his crop in the sale of both the seed and the straw. Selection of plants that have the longest straw combined with a good yield of seed will greatly improve the quality of the straw for fiber purposes. On the other hand, the selection of heavy-yielding plants and their increase into sufficient quantities for field planting can be carried out along the lines recommended for the improvement of the small grains (See index). The greatest improvement, however, can be made by developing wilt-resistant strains. Excellent work has already been done in this direction, but much remains to be accomplished. The best results come from selection of resistant strains in the locality in which they are to be grown. The plants which mature in a field attacked by flax wilt should be harvested and the seed carefully saved. Only by growing these resistant plants can strains not subject to the disease be developed.

LABORATORY AND FIELD EXERCISES

1. Mount specimens of the plant and the fiber and thread made from it. Add also a piece of fabric.

2. Press some seeds and watch for traces of oil, or boil some and see whether oil rises to the surface.

3. Samples of seed may be judged on the size and uniformity of the grain, freedom from green and shriveled seed, and freedom from other grains, weed seeds, and trash.

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CHAPTER IX

MISCELLANEOUS GRAIN CROPS

RICE

299. Origin and History. Rice is one of the oldest of cultivated plants, its cultivation in China dating back at least 4,000 years. It is evidently a native of that country, for it still grows wild in the southern portion. Rice was carried from China into India, then into western Asia, Egypt, and southern Europe. Its introduction into the United States is said to date from 1694, when a small quantity was brought to Charleston, South Carolina. Its cultivation soon became quite general in the low lands along the Carolina coast, but it was not grown on a large scale elsewhere in North America until within the last thirty or thirty-five years.

300. Botanical Characters. Rice does not differ materially in its growth from the other cereals. Botanically, the rice plant is known as *Oryza sativa*. Its nearest relative in a wild state in the United States is the wild rice of the swamps; *Zizania aquatica*, which is used as food by the Indians and to a limited extent by white men. The culms of cultivated rice usually reach a height of from 4 to 5 feet, several culms being produced from one seed. The flowers are produced in compact panicles; the spikelets, which are one-flowered, are on short pedicels. The outer glumes are short scales; the inner or flowering glume, which incloses the kernel, is sometimes awned. The flowering glume and palea together make up the hull, or husk, which is usually yellowish brown in color. The inner portion of the grain is hard and white. Rice which is enclosed in the hull is known as paddy; that from which the hull has been removed is known as cleaned rice.

301. Varieties. The two general types of rice are the lowland and the upland. The former is grown on rather low, level land which can be flooded from wells or streams, while the latter is produced without irrigation. The lowland is the type grown almost entirely in this country. The variety most commonly grown in South Carolina is the Carolina

Figure 88.—The two common types of rice grown in America: Honduras on the left, a Japanese variety on the right

Gold, with golden-yellow hulls. In Louisiana and Texas, the types usually grown are the Honduras and the Japan. Both are yellowish brown in color; the grains of Honduras rice are larger and longer, but relatively thinner, than those of the Japan type. Though Japan rice is of comparatively recent introduction, large quantities of it are now grown.

302. Importance of the Crop. Rice is one of the world's greatest food crops, being a staple article of diet for several hundred millions of people in India, China, and Japan. The total annual production of cleaned rice, besides China, is from 100 to 120 billion pounds, indicating an annual production of rough rice, or paddy, of about 160 to 190 billion

pounds, as compared with the world's wheat crop of 204,000,000,000 pounds, and a slightly smaller corn crop. By far the greater part of this enormous crop is raised in Asia. India has an annual production of 70,000,000,000 pounds of cleaned rice, and Japan 18,000,000,000 pounds. The total European production of rice amounts to about 1,000,000,000 pounds annually, most of which is grown in Italy and Spain.

In comparison with these figures, the production of rice in the United States is insignificant, the average yield for the three years from 1918 to 1920 being only 1,235,000,000 pounds. Practically all this crop is grown in the four states of Louisiana, Texas, Arkansas, and California. In slavery times, South Carolina produced most of the rice grown in the United States, but after the slaves were freed the industry rapidly declined. The fields along the Atlantic Coast are small and not adapted to the use of modern seeding and harvesting machinery, while the level plains of Louisiana and Texas, with abundant water for irrigation from wells and rivers, furnish ideal conditions for the cheap production of rice on a large scale. Since the introduction of modern machinery into this district, about 1885, there has been an immense increase in the production of rice, and the United States now exports considerable quantities of rice annually. In the five years from 1918 to 1922, 568,000 acres were devoted to rice annually in Louisiana, 220,000 acres in Texas, 154,000 acres in Arkansas, and 141,000 acres in California. The average yield to the acre was about 37.6 bushels of rough rice of 45 pounds each, equivalent to about 1,110 pounds of cleaned rice. The total crop of the United States was valued at $65,000,000. This is nearly one third less than the value of the rye crop.

303. Conditions Necessary to Production. The conditions which are necessary to the successful production of lowland rice include a soil which retains moisture and is level enough to be readily irrigated, an abundant supply of

water for irrigation, and a warm growing season. The fertile river valleys and plains of Arkansas, Texas, Louisiana, and central California are ideal for the production of this crop.

304. Growing the Crop. The methods of preparing the land for rice as practiced in the rice-growing states are not different from those used in the Northern and Central states for other cereals. The land is usually plowed in the spring and is disked and harrowed to form a good seed bed. To prevent too rapid loss of water from a loose soil, newly plowed land is sometimes rolled. The seed is generally sown with a grain drill at the rate of from 2 to 3 bushels to the acre, usually from April 15 to May 15. The seeding and harvesting seasons may extend over a considerable period on a given farm, thus enabling the farmer to put in a comparatively large acreage with a small equipment. Water is not usually applied to rice fields until the crop is about 8 inches high; then it is let in to a depth of from 3 to 6 inches, and this depth is maintained till the crop is nearly mature. To prevent the water from becoming stagnant, a practically continuous flow is provided, with drainage to maintain the proper level. When the crop begins to ripen, the water is drawn off to allow the ground to dry out sufficiently for harvesting. The ordinary grain binder is used; the methods of harvesting, stacking, and threshing are not different from those used with other grains.

305. Uses of Rice and Rice Products. Rice is mostly used as human food. In the United States, the milling process consists in removing the hull and inner skin of the grain and in polishing the kernel between pieces of sheepskin to give it the luster required by the American trade. The Orientals dispense with this polishing process, and thus retain a large part of the food value of the rice which we lose. The portion of the rice kernel which is removed in the polishing process is more valuable relatively than that which

remains, as it contains nearly all the fat. Polished rice contains of digestible nutrients 4.6 per cent of protein, 72.8 per cent of carbohydates, and 0.4 per cent of fat. The by-products of the milling industry are rice hulls, rice bran, and rice flour or polish. Rice hulls are of little value except as fertilizer or mulch, for they contain a large percentage of fiber and little nutriment. Rice bran and rice polish, however, are both valuable stock feeds. Rice straw is about equal in feeding value to prairie hay, and is quite largely used as rough feed for stock. It is also used to some extent in the manufacture of straw hats, strawboard, and other articles.

THE GRAIN SORGHUMS

306. Origin and History. The sorghums which are grown in various parts of the world for grain and forage for the most part have been developed in Asia and Africa. A large number of very diverse forms has been produced, including the many sweet or forage sorghums, the grain-bearing varieties such as kafir, milo, and durra, and the fiber-producing type, represented by broomcorn. The grain sorghums are important crops for the production of food for man and animals quite generally in Africa, India, and portions of China. Their cultivation in the United States dates back only to about 1875, though some of the types had doubtless been grown at an earlier period, but had disappeared from cultivation.

307. Botanical Description. The various types of cultivated sorghums are all grouped by botanists under the head of *Andropogon sorghum*. This original type is still found quite generally in the warmer portions of the globe. In general, the sorghums are large annual grasses with tall, pithy stalks, growing from 4 to 10 feet high, and bearing the seeds in a rather compact branching head or panicle. The height of the stalk, the shape of the head, the size of the seeds, and other characters are decidedly variable in the

different types and varieties. Dwarf forms which do not grow more than 2 or 3 feet tall are known, while giant types reaching more than 15 feet in height have been imported from Africa. The heads vary from the close, compact form

Figure 89.—Sheaves of grain sorghums: 1, Red kafir; 2, Shallu; 3, Blackhull kafir; 4, White durra; 5, Brown kaoliang; 6, Yellow milo; 7, Dwarf milo.

of the durras to the wide spreading type of the broomcorns. The pith in the stalks of the grain sorghums is dry or contains little juice, while that of the forage or sweet sorghums (sorgos) is filled with sweet juice. The long branching panicle separates the broomcorns from the other types of sorghum with shorter branches. The sweet sorghums are

discussed under the heading of forage crops (Section 412). As the culture and requirements of broomcorn are quite similar to those of the grain sorghums, that crop is considered in this chapter.

308. The Types of Grain Sorghums. The grain sorghums usually grown in the United States are of two general types, kafir (kafir corn) and milo (milo maize). Four other types, known as durra, feterita, shallu, and kaoliang, are occasionally grown. The kafirs differ from the other grain sorghums in that the pith is slightly juicy, the peduncles are always erect, and the panicles cylindrical. The seeds are white, pink, or red. The milos are less leafy than the kafirs, the heads are ovate, and the peduncles are usually bent so that the heads turn downward. The seeds are slightly flattened and are usually yellowish-brown in color. The ordinary type is the yellow milo. The durras are quite similar to the milos, but the pith is always dry and the seeds are decidedly flattened. The seed is white or reddish brown in color. Feterita is an early maturing grain sorghum similar to durra, which has recently become quite popular in some sections of Kansas. The kaoliangs and shallu are recently introduced types and are as yet of little importance.

309. Importance of the Sorghums. The grain sorghums are largely grown in India, the warmer portions of China, and Africa. In the United States, they are almost entirely confined to the Great Plains area, the country lying between the 98th meridian and the Rocky Mountains. In western Texas, Oklahoma, Kansas, and Nebraska, they are important crops. Only the earliest maturing varieties can be grown as far north as South Dakota, or at the ordinary elevations in New Mexico and Colorado. Sorghums are grown to some extent in the interior valleys of California, the type most common there being white durra, locally known as Egyptian corn. The value of the grain sorghum lies in its ability to resist drought and to mature a crop of grain with little rain-

fall. It supplies a cultivated crop to use in rotation with the small grains in sections where the production of corn is uncertain, and takes the place of that grain for feeding to stock. The average area devoted to the grain sorghums in Kansas in the five years from 1918 to 1922 was 1,241,000 acres. In the same years, Oklahoma averaged 1,438,000 acres of these

Figure 90—Harvesting kafir for forage with a corn binder.

crops and Texas averaged 1,906,000 acres. The average of these three states and of Colorado, New Mexico, Arizona, and California is 109,151,000 bushels, or nearly half more than the total production of rye in the same years.

310. Methods of Growing the Crop. The usual methods of preparing the land, planting the seed, and cultivating the grain sorghums are not different from those employed in the same district for the corn crop, except that the seed is sown more thickly in the rows. The plants should stand about 4 to 6 inches apart for the best yield of grain and forage. From 4 to 6 pounds of seed will plant an acre. The sorghums are usually planted a little later than corn, as they are not quite as resistant to cold and grow very slowly till warm, settled weather. The crop is usually harvested by cutting it

with the corn binder and shocking it like corn, or by cutting the heads from the stalks with knives or with some form of header. The shocked sorghum may then be fed to stock like corn fodder, or it may be threshed like small grain. The kafir and milo heads may be stored in cribs like corn and fed without threshing, or they may be threshed like wheat or oats and only the threshed grain used for feeding.

311. Value of the Grain. Most of the grain sorghum crop is used for feeding to stock, for which purpose it is nearly as valuable as corn. The seed is fed either whole or crushed; slightly better results are usually obtained from the crushed grain. The grain sorghums make up a large part of the prepared poultry feeds which are on the market, considerable quantities being used annually for this purpose. Only a small portion of the crop is used for human food, though very palatable breakfast foods, bread, and pancakes may be prepared from kafir and milo. The stalks and leaves of kafir, when properly cured, are fully as good for forage as the same parts of the corn plant. Milo is less leafy than kafir and the stalks are less palatable, so that milo stover is less valuable than that from kafir.

BROOMCORN

312. Culture. Broomcorn is not a grain crop nor can it be included with any other important class of crops, but it is so closely related to the grain sorghums that it can best be discussed with them. The methods of growing the crop are not different from those employed in the production of corn and the grain sorghums. Broomcorn is of two general types, the standard and the dwarf. Standard broomcorn grows from 8 to 10 feet high and produces a long, slender, rather flexible brush; dwarf broomcorn grows from 4 to 6 feet high and usually produces a shorter, stiffer brush. The crop is grown principally in Illinois, Missouri, Kansas, and Oklahoma; the standard type is more largely grown in cen-

tral Illinois than elsewhere. It requires a fertile soil and plenty of moisture, while dwarf broomcorn produces brush of the best quality on light sandy land. Dwarf broomcorn resists drought better than the standard, and is grown most extensively in Kansas and Oklahoma. The usual width between rows of the standard is 3½ feet, with the plants 3 inches apart in the row; dwarf broomcorn is planted in rows 3 feet apart with the plants 2 inches apart in the row. From 3 to 5 pounds of seed are planted to the acre.

313. Harvesting. Dwarf broomcorn is harvested by pulling the heads from the stalks by hand when they are in bloom, as the brush is of inferior quality when the seeds mature. The brush is then thrown into wagons and hauled to the thresher. Standard broomcorn is harvested by "tabling" before the heads are removed from the stalks. In tabling, the stalks are bent over about 2½ feet from the ground, two rows being bent together so that the heads of each extend about 2 feet beyond the other. The brush is removed by cutting the stalk with a small knife, about 6 inches below the base of the head. The heads are laid in bunches on the "tables" as they are cut and are then hauled to the thresher. The seed is removed from the brush by a machine specially built for the purpose. The heads are carried to the cylinders on a toothed belt which runs at an angle to them so that the heads do not go completely between them. The upper portion of the heads passes between the cylinders sufficiently to remove the seed, and the brush is deposited on a table at the other end of the machine, from which it is taken to the curing shed. In harvesting, poorly formed heads should be left in the field, while crooked or discolored brush should be sorted out in threshing.

314. Curing and Marketing. The curing is done in a well-ventilated shed which may be used for storing machinery or for other purposes during most of the year. The cleaned brush is placed on temporary slatted racks in layers 2 or 3

inches deep, with an inch or two of air space between the layers. Curing under cover is necessary to retain the desirable green color of the brush, and to prevent it from becoming brittle or discolored. From two to four weeks of dry weather are required for curing, after which the brush should be neatly piled together or "bulked" to prevent bleaching. After it is thoroughly dry, it is ready for baling. Broomcorn goes to market in bales of from 300 to 400 pounds in weight, the baling being done by horse-power presses. The price varies greatly with the size of the total crop and the length and quality of the brush. It ranges ordinarily from $50 to $100 a ton, though it may reach $200 or more in years when the crop is short. A good crop of dwarf brush is about 400 or 500 pounds to the acre, while standard broomcorn will produce from 600 to 800 pounds.

BUCKWHEAT

315. Origin and History. Buckwheat is one of the few grains which do not belong to the grass family, flax being the only other one which is of importance in America. It is a member of the dock or buckwheat family, the *Polygonaceae*, which includes few useful plants, but numerous bad weeds such as the docks, smartweeds, and knotweeds. A peculiarity of this family is the three-angled (rarely four-angled) seeds. The ordinary buckwheat, *Fagopyrum esculentum*, is a native of the Amur River district of Manchuria, where it is still found growing wild. A type which is grown to some extent in Maine and Vermont is the Tartary buckwheat, or "India wheat," *Fagopyrum tartaricum*, with smaller seeds, broader leaves, and more slender growth. This plant is a native of the plains in the interior of Siberia and Tartary. It was brought from Europe to the United States by the colonists. The name buckwheat is supposed to have been originally "beech-wheat" from the resemblance of the grain to small beech nuts.

316. Botanical Description. The buckwheat plant is entirely different from that of the cereals, consisting of a single branching, succulent stem, broad leaves, and a main root with several branches. The plant grows usually about 3 feet tall, with several branches, each of which ends in a flat-topped cluster of flowers. These clusters also spring from the

Figure 91—Grains of the two most common varieties of buckwheat: Japanese at the left, Silverhull at the right.

axils of the leaves. The leaves are alternate, triangular, and about as broad at the base as they are long, the width varying from 2 to 4 inches. The flowers are white or pinkish-white, without petals, but with a five-parted calyx, eight stamens, and a three-parted pistil. The flower produces a single three-angled seed, grayish or brown in color, about one tenth of an inch long.

317. Varieties. The most common varieties of the ordinary buckwheat are the Japanese and the Silverhull. These differ mainly in size and color. Silverhull is smaller and plumper and lighter in color than Japanese. Opinions differ as to which produces the more grain and the better quality of flour. Tartary buckwheat is smaller than the ordinary type and, according to growers in Maine, is somewhat hardier. It probably yields less than Japanese and Silverhull.

318. Importance. The entire area devoted to buckwheat in the United States is only about 800,000 acres annually, though in 1918 it was slightly over 1,000,000 acres. About two thirds of the crop is grown in New York and Pennsylvania. The average production of the United States in the five years from 1918 to 1922, inclusive, was 14,741,000 bushels, of which New York grew 4,468,000 bushels and Pennsylvania 5,075,000 bushels. No other state produced more than a million bushels, the states of largest production being West Virginia, Ohio, and Michigan. Except in New York and Pennsylvania, buckwheat can not be regarded as a staple crop, but is generally sown as a filler or catch crop on land where corn or some other early planted crop has failed. It yields well on poor land, hence it is grown quite generally on rocky hillsides and other dry locations. The best yield is produced on sandy loam soils. The chief value of buckwheat lies in its quick maturity, enabling it to ripen its seed when sown as late as July 1, thus giving an opportunity to get some return from fields where previous crops have been destroyed by floods or from other causes. As it makes a quick, rank growth, it is also an excellent crop for clearing land of weeds and for green manure.

319. Method of Cultivation. Buckwheat should be sown on well-prepared land during the latter part of May or in June. Seeding as late as July 1 is possible where the growing season is not too short. The usual rate of seeding is about 3 or 4 pecks to the acre. The seed may be sown broadcast or with the grain drill. If sown broadcast, it should be well covered with the harrow. Cutting is usually delayed till the approach of cold weather, as the plants continue to bloom and produce seed until killed by frost. The usual method of cutting is with the self-rake reaper, the grain being cured in the bunches and not tied into bundles. These bunches are often set up into shocks to lessen the injury from weathering. Cutting with the grain binder is sometimes

practiced. The bundles should be made small and should be set up in long shocks to facilitate curing. The grain is usually hauled direct from the field to the threshing machine and threshed, because it is likely to mold if stacked.

320. Uses. Buckwheat is most largely used for the manufacture of pancake flour. In some sections, however, it is quite extensively used for feeding to stock. For hogs, it is ground and bolted to remove the hulls, but this extra work is hardly necessary when the grain is fed to other animals. Buckwheat is also an excellent poultry feed. The straw is coarse and stiff, so that it is of little value except as bedding or to make manure. The buckwheat plant is a large producer of honey, small fields often being sown for bee pasture.

THE MILLETS

321. Types of Millet. The term "millet" includes a number of very different types of grasses, though it is generally applied in this country to two plants, the foxtail millets, *Chaetochloa italica*, and the broomcorn, or hog, millets, *Panicum miliaceum*. Both these plants probably originated in southwestern Asia, and have been cultivated there since very early times. They have been used as food plants for many centuries, and are still important items of food in the interior of China and in other portions of Asia, as well as in Russia. The foxtail millets are more generally grown in this country for forage than for grain. They are more fully discussed in Section 424.

322. Broomcorn Millet. Broomcorn, or hog, millet, sometimes known as proso, has been grown in the United States only in recent years, having been introduced by immigrants from Russia. The plant grows from 1 to 2 feet high, with numerous broad, hairy leaves and stiff, hollow stems. The heads are usually loose, open panicles resembling small heads of broomcorn, though in some varieties the branches

of the panicle are much shorter, making a close head of the "lump" type. The cultivation of this crop is quite closely confined to the drier regions of the Northwest, North and South Dakota producing most of the broomcorn millet grown in the United States. The chief value of the crop lies in its ability to resist drought and to mature in a short season, the grain ripening in from 60 to 75 days from the time of seeding.

Figure 92—Heads of two types of broomcorn millet.

The method of growing these millets is not different from that employed in the cultivation of other small grains. They are usually sown about June 1, and are ready to harvest in August.

The proper rate of seeding is from 2 to 3 pecks to the acre. The crop is cut with the mower when the seed is in the hard dough stage, and is handled like hay. When the growth is tall enough, the grain binder may be used. The grain may be threshed with the ordinary threshing machinery. It makes a good feed to mix with other grains for cattle, sheep, and hogs, and is also excellent for poultry. Hay made from this class of millet is much less valuable than that from the foxtail type, because the stems are coarse and the leaves and stems are covered with coarse hairs, so that it is not relished by stock.

323. Varieties. The varieties of broomcorn millet are usually known by the shape of the head, the color of the seed, or the locality from which they originally come. Among the best and most popular varieties are the Black Voronezh and Red Orenburg.

LABORATORY AND FIELD EXERCISES

It is desirable that laboratory specimens of the plants discussed in this chapter or the threshed grain or both plants and grain be available for class use, so that they may be studied and the members of the class enabled to familiarize themselves with these little known or local crops. If any of these crops are important in the locality, careful studies of them should be made and exercises in judging given as suggested for the other grains.

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958. Standard Broomcorn.
1062. Buckwheat.
1162. Proso, or Hay Millet.

PART III—FORAGE CROPS

CHAPTER X

INTRODUCTION

324. Definitions. A forage crop is any crop the leaves or stems or both of which are used either green or dried for feeding to stock. The green plants may be grazed, when they constitute *pasture,* or they may be cut and fed green, as a *soiling crop.* The practice of feeding in this manner is called *soiling. Hay* is the cured or dried stems and leaves of the finer grasses and other forage plants. *Fodder* is the cured stems and leaves of corn, sorghum, or other coarse plants, cut just before maturity and fed without removing the grain. *Stover* is corn or other fodder from which the grain has been removed. *Straw* is the stems and leaves of grain crops from which the seed has been removed; it corresponds to the stover of the corn plant. Certain forage plants, of which corn is the principal one, may be cut green and stored in a tight enclosure built for the purpose (a silo), or occasionally they may be stacked without curing. In either case, the product is known as *silage.*

A *grass* is any member of the great order of plants known as the *Gramineae,* which includes not only the grasses as we commonly know them, but the cereals and many weedy plants as well. In the narrower sense in which it is commonly used, the term includes only the meadow and pasture plants of this family, though it is sometimes used as a general term for any plant grown in meadows or pastures, whether a true grass or not. A *legume* is a plant of the other great

group of forage plants, the *Leguminoseae*, which includes the clovers, alfalfa, cowpea, soy bean, and many others.

325. Importance of Forage Crops. The total area of the farms in the United States, according to the Census of 1920, was 955,884,000 acres, while the area of improved lands was 503,073,000 acres. Of this area of improved lands, 365,000,000 acres were in harvested crops, and 138,000,000 in woodlands, pastures, and orchards. The improved woodlands are practically all pastured, while the acreage in orchards is comparatively small. It is safe, therefore, to assume that 125,000,000 acres are used for pasture. Of the area in harvested crops, 81,618,000 acres, or about 16 per cent, were devoted to hay and other forage production. In addition, a very large part of the area not listed in farms, about 74 per cent of the total area of the United States, is used as pasture, including the range lands of the western prairies, the mountain slopes and valleys, and other lands not devoted to farming or too rough for improvement. The total acreage in harvested forage crops and improved pastures was something like 207,000,000 acres, as compared with 88,000,000 acres in corn and 130,000,000 acres in other grain crops.[1]

326. The Classes of Forage Crops. Practically all our forage plants belong to one or the other of the two great families, the grasses and the legumes. The more important forage grasses are perennial, and are used either for pasture or meadow. These include timothy, redtop, Kentucky blue grass, orchard grass, Johnson grass, and many others. The annual forage grasses are used either as hay or as soiling crops, though they may occasionally be utilized as temporary pastures. They include the millets and sorghums, and also the cereals that are sown for hay production in some sections of the United States. The leguminous forage plants may also

[1]It may be of interest to the student to compare the above percentages with corresponding figures for older settled countries, as England and Germany. See Agricultural Economics, by H. C. Taylor, and the Cyclopedia of American Agriculture for data.

be divided into perennials and annuals, the former class including such plants as alfalfa and the clovers[1], and the latter the cowpea, soy bean, field pea, and vetch. A few miscellaneous forage crops, usually used for soiling or pasture purposes, are included in the mustard family, the *Crucifereae*. These are rape, kale, cabbage, and kohl-rabi. Other plants are occasionally used as forage crops, but they are comparatively unimportant.

327. Forage Production in the United States. The more important kinds of forage are indicated in Table XIV, which shows the acreage, production, and value of the different classes of forage produced in the United States in 1919. This table shows that the most important class of forage is mixed timothy and clover hay. Next to this in acreage ranks the class which includes wild, salt, and prairie grasses, although alfalfa exceeds this class in production. Corn cut for forage ranks next in acreage, followed by timothy grown without a mixture of clover, and then by alfalfa. "Other tame grasses," small grains cut for hay, and kafir and sorghum for forage

Table XIV. Total acreage, production, and value of hay and other forage in the United States, Census of 1920.

Class of forage	Acres harvested	Production, tons	Value
Timothy alone	10,941,347	12,799,430	$315,040,745
Timothy and clover mixed	19,349,405	26,341,786	594,671,677
Clover alone	3,160,415	4,147,050	100,249,755
Alfalfa	8,624,811	18,853,133	416,178,534
Other tame grasses	6,055,657	6,403,805	133,181,607
Small grains cut for hay	5,674,854	5,462,853	120,229,829
Annual legumes cut for hay	1,846,914	1,716,195	47,094,363
Wild, salt, or prairie grasses	17,126,485	15,631,288	226,502,614
Silage crops	4,003,226	29,682,041	240,022,388
Kafir, sorghum, etc., for forage	4,746,849	7,912,973	112,854,077
Corn cut for forage	14,502,932	17,793,742	206,934,650
Root crops for forage	88,333	598,945	10,089,985
Total hay and forage	96,121,228	146,343,241	$2,523,050,224

[1] Red clover is ordinarily biennial.

follow next in order of acreage. Under "other tame grasses" are included all tame grasses other than timothy which are cut for hay.

The larger part of the forage is produced in the North Central states. This group, according to the Census classification, extends from Michigan and Ohio to Kansas, Neb-

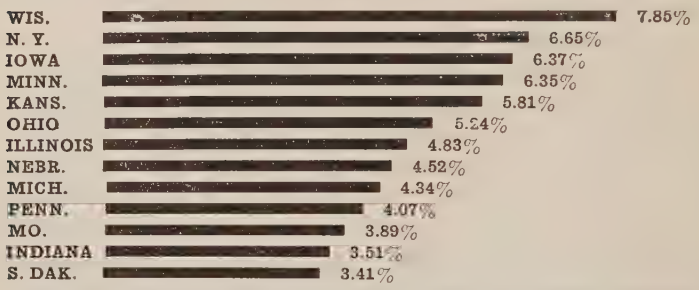

Figure 93.—Percentage of the hay and forage of the United States produced in each of the leading states, Census of 1920

raska, and the Dakotas. This district includes 56 per cent of the acreage and 58 per cent of the production of all forage crops produced in the United States. The leading states in the production of forage are shown graphically in Figure 93.

328. Uses of Forage Crops. The most important use of forage crops is as bulky feed for our domestic animals, either in succulent or dry form. Horses, cattle, and sheep are naturally adapted to the consumption of large quantities of forage, and pork can be produced most profitably when hogs are provided with abundant pasturage. Thus forage crops are very important in our farm economy. They enter more largely into the production of beef and milk in cattle and of mutton and wool in sheep, as well as of energy in horses, than the grains. In general, our farm animals are produced and maintained largely on forage, grains being used only at certain times, as in the fattening of sheep and cattle, when horses are at hard work, or when cows are producing milk.

Forage plants are also important as soil renovators, adding large quantities of vegetable matter to the soil in the form of decaying roots and stems. The perennial leguminous plants penetrate to a great depth and loosen and aërate the subsoil, as well as bring up plant food from greater depths than annual crops. A part of this plant food remains near the surface when the roots and stubble decay, or it is returned to the land in the form of manure. In this and in other ways, forage crops add to the fertility or improve the physical condition of the soil. Such annual crops as fodder corn and millet, however, draw rather heavily on the available supply of plant food and leave little vegetable matter behind, while they may injure the physical condition of the soil by reducing the moisture supply late in the season. The grasses and clovers, particularly the more permanent kinds, serve as cover crops to prevent the washing and erosion of the soil, thus preventing loss of fertility. On hillsides, embankments, and similar locations, they thus perform a very valuable work. Certain kinds also add much to the beauty of the landscape and to the home surroundings in the city as well as in the country, by covering the earth with a carpet of green during the summer season.

329. Essentials of a Forage Crop. One of the most important essentials of a forage crop is that it must be nutritious; that is, it must contain a considerable quantity of food for animals. Though the proportion of nutriment is less than in the grains, forage crops add bulk to the ration of ruminants, and aid in the digestion of more concentrated feeds. A good forage crop must also be palatable; for, no matter how nutritious it is, if it is not readily eaten by animals, it is valueless for the purpose. Some plants have a peculiar and offensive odor, or the stems and leaves are covered with hairs, or for some other reason animals do not eat them readily, though they may possess every other requisite of a good forage crop. Productiveness is likewise

Table XV. Total dry matter and digestible nutrients in 100 pounds of the leading forage crops.[1]

	Total dry matter in 100 pounds	Digestible nutrients in 100 pounds		
		Crude protein	Carbohydrates	Fat
Dried forage	Lbs.	Lbs.	Lbs.	Lbs.
Corn fodder	91.0	3.5	51.7	1.5
Corn stover	90.6	2.2	47.8	1.0
Timothy hay	88.4	3.0	42.8	1.2
Orchard grass	88.4	4.7	41.1	1.6
Redtop	90.2	4.6	45.9	1.2
Kentucky blue grass	86.8	4.7	43.5	1.5
Johnson grass	89.9	2.9	45.0	1.0
Oat hay	88.0	4.5	38.1	1.7
Oat and pea hay	83.4	8.3	37.1	1.5
Red clover	87.1	7.6	39.3	1.8
Crimson clover	89.4	9.7	36.8	1.0
Soy bean	91.4	11.7	39.2	1.2
Cowpea	90.3	13.1	33.7	1.0
Alfalfa	91.4	10.6	39.0	0.6
Wheat straw	92.9	0.7	39.6	0.4
Oat straw	88.5	1.0	42.6	0.9
Green forage				
Corn silage	26.3	1.1	15.0	0.7
Fodder corn	21.9	1.0	12.8	0.4
Sorghum	22.8	0.6	11.6	0.5
Pasture grass	20.0	2.5	10.1	0.5
Kentucky blue grass	31.6	2.3	14.8	0.6
Timothy	37.5	1.5	19.3	0.6
Rye forage	21.3	2.1	12.2	0.5
Oat forage	26.1	2.3	11.8	0.8
Bermuda grass	33.2	1.4	17.0	0.5
Hungarian millet	27.6	1.9	14.8	0.6
Red clover	25.3	2.7	10.4	0.4
Alfalfa	26.2	3.3	13.0	0.6
Cowpea	22.0	1.8	10.1	0.6
Soy bean	27.1	2.6	11.0	0.7
Field pea	27.9	2.8	13.1	0.9
Roots, etc.				
Mangel	9.4	0.8	6.4	0.1
Turnip	9.5	1.0	6.0	0.2
Rutabaga	10.9	1.0	7.7	0.3
Rape	16.7	2.6	10.0	0.3
Concentrates				
Corn, dent	89.5	7.5	67.8	4.6
Wheat bran	89.9	12.5	41.6	3.0

[1]These figures are based on Henry and Morrison's Feeds and Feeding.

important, for it is necessary that our forage crops yield well in order to obtain the largest returns from a given area and to support the largest possible number of animals.

A good forage crop must have good seed habits; that is, the seed must be produced quite abundantly, be easily harvested, and retain its germinating power reasonably well, in order that it may not be too expensive to justify its common use. It must be easily eradicated when it is desirable to replace it with some other crop. A perennial forage plant to be used in meadows and pastures must be vigorous and hardy enough to cope successfully with weeds and other unfavorable conditions of growth, yet its habit of growth must be such that it can be destroyed readily when the land is plowed and planted to some other crop. A few of our good forage grasses are desirable in every particular except this, but their usefulness is largely limited on account of the difficulty of disposing of them when desirable. Among crops of this class may be mentioned quack grass, Johnson grass, and Bermuda grass.

330. Comparative Feeding Values of Different Forage Crops. The amounts of digestible nutrients in 100 pounds of the more important forage plants are shown in the accompanying table. These figures are presented here for purposes of comparison, and reference will be made to them from time to time in the pages which follow. The digestible nutrients in corn and in wheat bran are also presented.

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CHAPTER XI

THE MAKING OF A MEADOW

331. The Essentials of a Good Meadow. One of the first essentials of a good meadow is that it be composed of plants that cure readily into hay, with as little loss as possible of leaves and other tender parts. Slowness in curing is likely to result in moldy or spoiled hay, while those plants which become brittle in curing break up readily in handling and a large part of the best food material is lost. The meadow should produce a good yield of palatable and nutritious hay. The plants which compose it should be thick enough to keep down weeds and to prevent the stems from growing so coarse that they are not eaten readily by stock. They should form a smooth, even turf rather than a bunchy one, as the bunches will soon become high enough to interfere with haying machinery. The field should be fairly level and free from stones and other obstructions, so that the hay crop can be harvested readily and economically.

332. The Formation of the Meadow. About one fourth of the land from which a hay crop is annually harvested is native meadow on which little or no attempt at improvement has been made. The Census of 1920 reports about seventeen million acres of wild grasses cut for hay. This native meadow is mostly in the more newly settled portions of the West. In the Central and Eastern states it has largely been replaced by the tame grasses and clovers, a large acreage of which is seeded every year for meadows and pastures. While specific directions for preparing the land and seeding will be given in the discussion of the more important meadow plants, some of the general principles which apply to the establishment of a meadow can best be stated here.

The land should be well prepared. Whether the grass seed is sown by itself or with a nurse crop, good preparation is essential to success. The seeds of all the grasses are small and many of them may fail to germinate in a poorly prepared seed bed, where they may not be covered at all or may be covered too deeply. A firm, moist, mellow seed bed with a fine, well-prepared surface, supplies the best conditions for germination and early growth. A smooth surface is also of material value when the crop is harvested, because haying machinery of all kinds works more easily and effectively on smooth ground than on rough. A well-prepared seed bed requires less seed than a poorly prepared one, for more of the seed will germinate.

The land should be fertile. It is useless to attempt to produce a profitable crop of hay on poor land. Most soils contain enough fertility to produce good hay crops if the proper selection of grasses is made, but usually the addition of manure will materially increase the yield. The time when the manure may be applied to best advantage depends on the time of seeding and whether the grass seed is sown with or without a nurse crop. When a nurse crop is used which is likely to lodge from manuring, it is better to apply the manure to some previous crop, or to delay its application till after the nurse crop is removed. On the other hand, if the meadow grasses are sown alone, a light dressing of manure may be plowed under with good results when the land is being prepared for seeding. It may also be applied as a top dressing after the grass seed has been sown, or any time later when it will not interfere with the growing crop.

333. Sowing in Mixtures. A mixture of grasses is frequently better than any one kind alone. There are exceptions to this rule, as when hay is grown for market that demands straight timothy or clover or alfalfa. Alfalfa ordinarily does better when sown alone than with any other plant. With most of the grasses, however, a mixture adds

to the yield and palatability of the hay crop. The yield is increased, because the roots of the different plants penetrate to varying depths, so that more food material is available for all than for any one. At the same time, the portions above ground grow to different heights, so that they have more space to spread when in a mixture than when growing alone. The palatability of the product is increased, for animals like variety in their food. Care should be taken in selecting the different plants to make up the mixture so that all will be ready to cut for hay at the same time. Red clover and timothy do not make the best mixture, as red clover is ready to cut earlier than timothy, and, if left till the timothy is ready, the clover stems become woody and many of the leaves drop off. Mammoth clover, which is later than red clover, is much better in a mixture with timothy.

334. Preparing the Land. The desirability of a well-prepared seed bed has already been stated. The method of preparing this seed bed varies with the soil, the locality, the season, and the preceding crop. A heavy soil usually requires more work to get it into good tilth for seeding than a loose, sandy one. Fertilization, either with barnyard manure or commercial fertilizers, may be necessary before seeding on the poorer lands of the South. If the land was plowed and put in good condition for the crop immediately preceding, some of this work may be omitted before sowing to grass.

The usual practice in the North Atlantic and North Central states, where most of the tame grass meadows are located, is to sow the grass seed with some grain crop. This may be winter wheat in the region where that crop is grown, or it may be spring wheat, oats, or barley. More attention than usual should be devoted to the preparation of the land when grasses are to be sown with these grains, particularly in the way of fining the surface soil before the seed is sown. When the grasses are to be sown with winter wheat, the land should be plowed some weeks previous to seeding time and

the seed bed prepared with the disk and smoothing harrows. If any of these grain crops follow corn which has been kept clean of weeds, a good seed bed can be prepared by disking two or three times and then harrowing. The corn rows should be leveled as much as possible in preparing the land. If the ground is to be plowed, deep plowing when the soil breaks up readily is desirable. Plowing when the soil is in proper condition reduces the labor necessary to obtain a good seed bed; fall plowing is usually preferable in the North. Deep plowing increases the water-holding capacity of the soil, and also increases the quantity of available plant food by making the soil more easily penetrable by the roots.

335. Selection of the Seed. The sowing of good seed is fully as important in forming a meadow as in the planting of any of the grain crops. The seed should be true to name, of strong germination, and free from noxious weed seeds. The seeds of some of the inferior grasses closely resemble those of some of the important ones; for example, Canada blue grass seed is very similar to that of Kentucky blue grass, but Canada blue grass is of much less value. When there is any doubt about the purity of the seed, a sample should be submitted to the nearest seed laboratory for examination. The experiment stations usually make examinations of this kind free of charge. With a simple hand lens and samples of good seed, or good illustrations of them such as are easily obtainable, examinations for purity may readily be made in school or at home[1]. Freedom from weed seeds is equally as important as freedom from undesirable mixtures, as many of the worst weeds are often introduced in grass and clover seed. Avoid them by not planting them.

336. Germination Test. As the germination of grass seed is often low, it is well to make a germination test of the

[1]Farmers' Bulletin 428, "Testing Farm Seeds in the Home and in the Rural School," gives directions for testing all the more important forage crop and grain seeds, with illustrations of these seeds and the more common impurities which are found in them. Farmers' Bulletin 382, "The Adulteration of Forage-Plant Seeds," is also a valuable aid to the making of purity tests.

seed before sowing or before purchasing it in quantity. A simple germinator may be made from two plates and two pieces of blotting paper or cloth, as shown in Figure 94. The cloths should be dampened and a definite number of seeds, one hundred or two hundred, placed between them. The second plate should then be put on as a cover and the germinator set in a moderately warm place, where there will not be any marked change of temperature during the day or night. The germinator should be examined occasionally to see that the cloths do not dry out. In about ten days, the seeds which show strong germination should be counted and the percentage of germination figured. If it is low, the seed should not be sown at all, or the rate of seeding should be increased sufficiently to supply the proper quantity of germinable seed. No sample which shows a low percentage of germination or any considerable proportion of impurities should be purchased. It does not pay to buy any but the best quality of grass and clover seed. Cheap seed is nearly always low in germination or contains large quantities of foreign seeds.

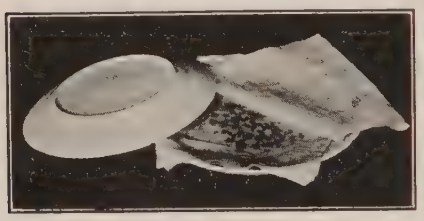

Figure 94.—Plate germinator for testing small seeds

337. Time to Sow. In the Northern states, the grasses are usually sown in the spring with the spring grains. In the winter wheat belt, timothy is generally sown in the fall with the wheat and clover is sown very early the following spring. Better results may often be obtained by sowing the timothy and clover together without a nurse crop in August or early in September, after winter wheat has been harvested. The land can be plowed and put in good condition immediately after the wheat is cut, and a good seed bed will then be ready for seeding at the proper time. The objection to this

method farther north is that the clover is very likely to kill out during the winter if not sown till late in the season. In the South, fall seeding of grasses is usually to be preferred.

338. Sowing with or without a Nurse Crop. While the plan of sowing grass seed with a grain crop is a very common one, the results which are obtained do not always justify its use. Instead of being a protection to the young plants, the grain crop is quite often the reverse, taking moisture from the soil when it is most needed. When the grain crop is removed, the young and tender plants which have previously been shaded are exposed to the full effect of the sun and wind and may be killed by a few hot days immediately following the harvesting of the grain. Little or no forage is usually produced by the new meadow the first fall after spring seeding and the hay crop produced the following year from August seeding is often fully as good as, if not better than, that produced from seed sown the previous spring with a nurse crop. With alfalfa and some other crops a nurse crop is seldom used.

339. Manner of Seeding. Grass seed may be sown broadcast by hand, with any of the ordinary broadcast seeders, or with a special attachment to the grain drill. The machine which is perhaps most generally satisfactory for this work is the wheelbarrow seeder. This gives an even distribution of the seed over the entire area, something which is not always easily obtained with most types of broadcast seeders. When sown with any of the broadcast seeders, it is customary to cover the seed by a light harrowing. The spike-tooth harrow is generally used for this work, though a brush harrow is sometimes employed. When clover is sown on winter wheat in the spring, it is not usually covered at all, the alternate thawing and freezing of the soil and the beating of the spring rains being depended on to cover the seed sufficiently for germination. Care should be taken that the seed is not covered too deep when sown with the grain drill.

340. Depth to Cover the Seed. The depth to which grass seed should be covered is important. With small seeds like those of the grasses and clovers, the danger is in covering too much rather than not enough. In dry seasons or in sections where the rainfall is scanty, deeper covering is necessary than under ordinary conditions, to reach moist earth. Seed may be covered to a greater depth in sandy soils than in those of a clayey nature. The proper depth of covering may often be obtained by rolling the field after the seed is sown, though a light harrowing is usually more effective. Covering to a depth of from one quarter of an inch to one inch will generally produce good results, though on sandy soils or in dry regions a greater depth of covering may be necessary. The seeds of Kentucky blue grass and many other grasses often germinate when they are not covered except by the natural movement of the soil particles.

341. Rate of Seeding. Definite statements with regard to the proper rate of seeding will be made in the special discussions of the various important hay crops, so only a few general rules will be given here. In mixtures, it is customary to sow enough of the more important grasses to give a full stand if the less important ones fail. The total quantity of seed in a mixture is usually greater than if any one of the constituents were sown alone. When clover and timothy are sown together, nearly as much seed of each is sown as when either is sown alone. The rate of seeding must be increased on poorly prepared land, to allow for the considerable number of seeds that will fail to germinate. When sowing a field that is to be used for the production of seed, less seed is used than when sowing for hay production. More seed is usually sown on wet land than on dry, and on rich land than on poor.

342. The Important Meadow Plants. The most important plants in American meadows are timothy and red clover. Alfalfa is the great hay plant of the West, and its

cultivation is rapidly spreading in all parts of the country. On wet lands, redtop is an important grass, and alsike clover largely replaces red clover. In the South, Johnson grass is the most common hay grass. In the Northwest, brome grass occupies a prominent place. The native meadows of the West are made up of a large number of species of native grasses, among the more important of which are the wheat grasses. A few others are used in a limited way in some sections of the country, but the six or seven plants named above constitute the greater part of the hay which is produced in the United States. These will be discussed at length in the succeeding pages.

343. The Care of the Meadow. To get the best results from a meadow, something more is necessary than to go out at the proper time and harvest the hay crop. The length of time a field is to remain in meadow influences to some extent the treatment which is given to it. The ordinary practice in this country, except with alfalfa, is to cut but one or two crops of hay and then break up the sod for some annual crop such as corn, potatoes, or small grain. Often it is pastured for from one to three years and then plowed and planted to some one of these crops. Little attention is given to the maintenance of permanent meadows except on land that is very wet or is otherwise undesirable for cultivation, though in England and some of the other European countries lands are kept continually in grass for many years.

Attention may well be given to the meadow during the first season in the matter of keeping down weeds and preventing them from seeding. Fields that are seeded to grass with a nurse crop in the spring often grow up to ragweed and other pests after the nurse crop is removed. These weeds should be prevented from seeding by going over the field with a mower about the time they begin to bloom, cutting the stubble rather high so as not to expose the roots of the young grass plants to the full glare of the sun's rays. Pas-

turing new seeding is not often advisable, though it is a very common practice. If a rank, heavy growth is made in the fall, it may be pastured to some extent without injury, but the quantity of forage produced is usually small, and the hay crop of the succeeding year is often reduced materially by fall pasturing. Enough top growth should be left to give ample protection to the roots during the winter. The fall growth of leaves also furnishes a supply of food material to the roots, which is stored over winter and used in the early growth of the plants the following spring. If the meadow is closely pastured in the fall, this supply of plant food is lessened, with a corresponding reduction in growth the next year.

If the stand of grass is thin in the spring following seeding, it can sometimes be thickened and the yield of hay increased by scattering grass seed over the field and covering it with the smoothing harrow. If the field is to be kept in meadow for two years, a top-dressing of manure or of commercial fertilizer in the fall or winter will materially increase the yield the following season. If commercial fertilizer of a readily available nature is used, it should be put on in the spring rather than in the fall, or much of it will be lost by leaching during the winter. Disking or harrowing grass lands is sometimes advocated to induce a more vigorous growth, but this treatment is unnecessary on meadows that are maintained for only one or two years.

344. Use of the Aftermath. "Aftermath" is the term usually applied to the growth made by a meadow after the main crop of hay has been removed. This aftermath is utilized in various ways, for the production of hay, pasture, seed, and green manure. The quantity of hay produced by the aftermath is usually much smaller than the main crop. The aftermath is more generally utilized as pasture than for the production of hay, because the regular pastures often fail in the late summer, and the extra pasturage is needed. If the meadow is to be used for the production of hay the

following year, the aftermath should not be pastured too closely. The second crop of clover is often cut for seed, because conditions are more generally favorable for seed production then than earlier in the season. If the meadow is to be broken up and put into some other crop the following year, the aftermath may often be used to best advantage by turning it under in the fall to add vegetable matter to the soil. Pasturing the meadow in the fall and then turning under the sod makes a double use of the fall growth, for much of the fertility is returned to the land in the manure, but the quantity of vegetable matter is slightly reduced.

345. Permanent Meadows and Their Improvement. The short-term rotation is in such general use in this country that little attention has been given to the formation of permanent meadows, and there is considerable question whether they are generally desirable. On lands which are too wet for cultivation, permanent meadows may often be established advantageously, but elsewhere, with the exception of alfalfa meadows, two years is about the longest time for which maximum yields can be expected. Insect pests and plant diseases can be combated much more effectively in a short rotation than in one in which any one crop occupies the land for a considerable period, and, as these troubles are generally present, they furnish strong reasons against the maintenance of permanent meadows. Where it is desirable to maintain a field in meadow for a number of years, special care should be given to the selection of long-lived grasses. Disking or harrowing every second or third year to prevent the field from becoming "sodbound," applying well-rotted manure, and reseeding the bare or thin spots, will result in profitable yields.

346. Place in the Rotation. The hay crop usually follows a small grain and precedes a cultivated crop. A common rotation in the Central states consists of two years of corn, one of oats, and one or two of grass. The meadow

may then be utilized as pasture for a year or two before it is again broken up for corn, or corn may immediately follow. Where winter wheat is an important crop, it may immediately follow the breaking up of a meadow and in turn be followed by corn. In this case, the land is again seeded to grass, with a second wheat crop following the corn. A slightly different arrangement of this rotation is corn, wheat, wheat, grass. If both wheat and oats are grown, the rotation may be corn, oats, corn, wheat, grass, or the order of the wheat and oats crops may be reversed, though wheat is the better nurse crop. In Maine and some of the other important potato-growing sections, the common rotation is potatoes, oats, hay. This hay crop is usually clover. (See Section 456). In the South and West, perennial hay crops other than alfalfa are so seldom grown that definite rotations have not been devised.

LABORATORY AND FIELD EXERCISES

Samples of seed of the common forage grasses should be obtained and examined for purity and germination. As soon as these seeds become familiar, mixtures containing two, three, or more of them may be separated into their component parts. At this time, all that need be done would be to separate the weed seeds, chaff, etc., from the good seed without any attempt to identify the weeds. Later, the different weed seeds might be identified. Several laboratory periods may well be devoted to this work. The student should also familiarize himself with the common grasses, clovers, and weeds growing in meadows in the neighborhood.

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CHAPTER XII

HAY AND HAY-MAKING

347. Principal Hay Plants. The principal perennial hay plants in the United States are timothy and clover in the North Central and Northeastern states, Johnson grass in the South, and alfalfa in Kansas, Nebraska, Oklahoma, and the Rocky Mountain and Pacific states. Among other perennial hay plants which are grown in more or less limited areas are redtop, orchard grass, brome grass, western wheat grass, and alsike clover. Numerous annual plants are also grown for hay, including foxtail millet, field peas, cowpeas, soy beans, wheat, rye, barley, oats, and hairy vetch. Any of these plants may be grown alone, or they may be grown in various mixtures of two or more.

348. Production of Hay in the United States. The greater part of the hay grown in the United States is produced in the Northeastern and North Central states. The Western states are coming to be of considerable importance as producers of hay, largely through the general use of alfalfa on irrigated land, with its high yield per acre. New York produces nearly one tenth of the annual hay crop of the country, while New York, Iowa, and Pennsylvania, the three leading states, show an average annual yield of about one fourth of the entire crop of the United States. The production of hay is, however, more generally distributed than that of any of the cereal crops except corn.

The annual production of hay in the United States for the five years from 1918 to 1922, as reported by the Bureau of Statistics, averaged 86,060,000 tons, grown on 58,144,000 acres and valued at $1,410,477,000. This is slightly more than the average annual value of either the cotton or the

wheat crop for a like period, though both these crops have sometimes exceeded hay in value. The average annual acreage production, and value of the hay crop in the ten leading states and in the United States during the five years from 1918 to 1922 are shown in Table XVI, while the percentage of the crop produced in each of the leading states is shown graphically in Figure 95.

Table XVI. Average acreage, acre yield, production, and farm value of tame hay in each of the ten leading states and in the United States, during the five years from 1918 to 1922, inclusive.

State	Area	Acre yield	Production	Farm value Dec. 1
	Acres	*Tons*	*Tons*	*Dollars*
New York	4,776,000	1.26	6,020,000	115,914,000
Wisconsin	2,965,000	1.60	4,750,000	84,528,000
Iowa	3,197,000	1.45	4,617,000	65,276,000
California	2,183,000	2.11	4,563,000	74,486,000
Ohio	3,157,000	1.36	4,308,000	73,137,000
Illinois	3,244,000	1.32	4,283,000	75,250,000
Pennsylvania	2,973,000	1.39	4,141,000	84,148,000
Missouri	3,124,000	1.14	3,562,000	53,771,000
Kansas	1,704,000	2.09	3,488,000	44,401,000
Michigan	2,830,000	1.18	3,347,000	58,926,000
All others	27,991,000	1.54	42,981,000	680,640,000
United States	58,144,000	1.48	86,060,000	1,410,477,000

The Bureau of Agricultural Economics reports tame and wild hay separately. When the production of wild hay is added, New York still leads, with Minnesota, Nebraska, Iowa, and Wisconsin following in order, with 5,200,000 to 5,700,000 tons each.

349. Acre Yield and Value. The heaviest yields of hay to the acre are obtained in the irrigated states of the West and Southwest. The principal hay crop grown in these states is alfalfa, of which several cuttings are made each year. The average acre yield of hay for the five years from 1918 to 1922 in Arizona was 3.26 tons; in Idaho, 2.68 tons; and in Nevada, 2.55 tons. In the states of largest production

the average annual yield ranges from 1.25 to 1.50 tons to the acre. The same range is quite general in the South. Much larger yields may be produced with special attention.

The average acre value of hay for the five years from 1918 to 1922 was higher in Arizona than in any other state, $67.74; or about $21.00 a ton. The lowest acre value was

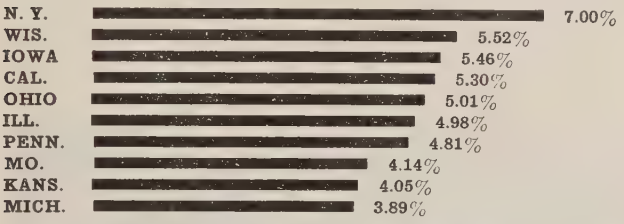

Figure 95.—Graph showing percentage of the total tame hay crop of the United States produced in the ten leading states during the five years from 1918 to 1922, inclusive.

that of North Dakota $12.99. The acre value in New York was $25.34 and in Iowa, $27.71. The higher price per ton in New York almost overcame the higher acre yield in Wisconsin, as the acre value is nearly the same.

350. Time to Cut. For the best quality of hay, the crop should be cut when the plants are in bloom. The grasses usually increase in weight and in total feeding value up to the time the seed begins to ripen, but they decrease in palatability and digestibility after the blooming stage is past. Probably the largest quantity of digestible food material can be obtained from hay made up largely of the grasses, if they are not cut until about the time they go out of bloom. On the other hand, the clovers and alfalfa must be cut somewhat earlier, or many of the leaves will be lost in curing and the feeding value will be considerably decreased. When red clover and timothy are grown together, the clover comes into bloom some days earlier than the timothy, and it is necessary to cut the crop when the clover is rather mature and before the timothy has reached its best state. Other-

wise, the decrease in value of the clover will more than equal any gain there may be from the timothy. Where the acreage to be harvested is large, it is necessary to begin cutting before the crop has reached the best stage in order to complete the work before a part of it becomes overripe.

Figure 96.—A good crop of hay ready to be hauled to the barn. The hay loader which takes the hay from the swath or windrow is generally used in large meadows. It is not then necessary to place the hay in cocks as shown here.

Whenever possible, hay should be cut when there is prospect of good drying weather until it can be put in the mow or stack. Conditions frequently make this difficult, but the best quality of hay can be made only when there is the least possible exposure to the weather. Hay that is fairly mature can often be cut in the morning and put in the stack or mow in the afternoon. Discoloration from dew and consequent lowering in market value are thus avoided. The same result can often be obtained by cutting late in the afternoon, so that the grass is still green and full of moisture when the dew falls. It will not then be discolored, and, unless rain falls during the night, will cure earlier in the

day than hay that is not cut till the following morning, and can be more readily stored.

351. Method of Cutting. Practically all the hay in the United States is now cut with the mower, though small acreages of swampy or rocky land in New England and elsewhere are cut with the scythe. Ordinary mowers cut swaths from 5 to 7 feet wide. One-horse mowers are made which cut a 3½ or 4-foot swath, but usually two horses are used with a machine cutting 5 or 6 feet in width. Cutting a swath more than 6 feet wide is hard work for two horses, and it is also difficult to keep long cutter bars in line.

352. Curing. The length of time required to cure a crop sufficiently for storing depends on the stage of maturity of the crop, the particular plant or plants which are to be made into hay, the yield, and the weather conditions. No general rules can be laid down. The point is to get the hay dry enough for storing with the least possible loss of food value and palatability. The food value may be reduced by washing by rains, by bleaching from rains or dews, by the loss of leaves and other tender parts when the crop is too mature or too dry for handling, and by the molding or rotting of the hay. Curing in the windrow or in the cock is desirable in order to prevent much loss of leaves, particularly in clover and alfalfa hay. Clover hay should not be handled more than is absolutely necessary after it is cured.

The use of modern machinery, such as side-delivery rakes and the hay loader, does away entirely with the cock, for the hay is taken up directly from the swath or the small windrow. This plan is often necessary on account of the scarcity of labor, but it is generally followed at a sacrifice in the quality of the hay. Curing partially in the swath and then raking it into cocks, which should be rounded up with a fork, if there is danger of rain, will give the best quality of hay. If hay of particularly high quality is desired in humid sections, the cocks should be covered with canvas covers.

Figure 97.—Haying scene on a Nebraska farm. The hay is raked into windrows and is then drawn to the stack on push rakes. The two horses, standing apart directly in front of the stack, are attached to one of these rakes, which has just brought to the stack the hay that is being elevated to it. Another rakeful is being brought up by the team beyond the stack.

353. Haying Machinery. Haying tools form a considerable part of the equipment of the farm. There is the mower, with which to cut the grass; the tedder, for stirring heavy hay in the swath to facilitate its curing; the rake, either of the hand-dump or self-dump type to gather the cured hay into windrows and then into cocks, or the side-delivery type which makes a continuous windrow, thus

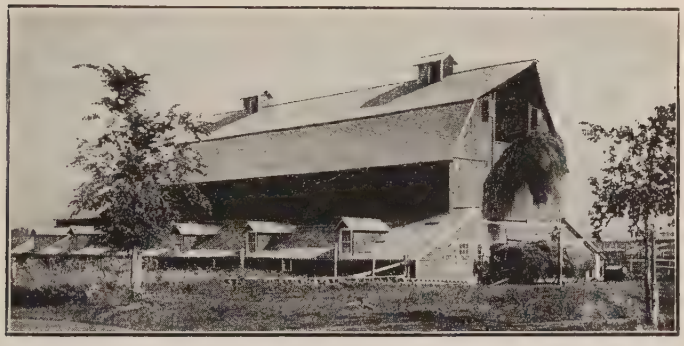

Figure 98.—Putting hay into the mow by means of slings. In this way, a load of hay can be put into the barn in a few minutes. This barn has a large mow capacity.

facilitating the use of the hay loader; the hay loader for taking the hay from the swath or windrow and depositing it on the wagon; and various arrangements of hayforks, slings, poles, tracks, pulleys, etc., for unloading the hay from the wagon to the mow or stack.

354. Storing. When the hay is properly cured, it should be placed as quickly as possible in some permanent place for storage. This may be in the mow of a barn, under a shed-roof built specially for protecting hay from the weather, or in a stack in the open. When the hay is to be fed on the farm and storage room can be provided in the barn without much expense, it should be placed there. It is then protected from loss by exposure to the weather and is conveniently located for feeding. If any quantity is to be stored

in the barn, a track and carrier should be placed in the peak of the roof and provision made for unloading by horse power.

When the mow does not afford sufficient storage room, particularly when the hay is to be sold rather than fed, a specially constructed hayshed may be useful. This consists of a set of posts covered with a roof, under which the hay is stored. If desired, the sides and ends may be enclosed; but this is not essential, as there will be little loss from weathering if the sides of the pile of hay are kept straight, so that rain and snow cannot penetrate. Where there is an abundance of hay and insufficient storage space under cover, stacking in the open is necessary. Where a number of loads are to be put into one stack, unloading is facilitated if a set of poles or derricks is used and the hay is unloaded with horses. Small stacks expose relatively more surface to the weather than large ones, and a greater proportion of the hay is injured by weathering.

355. Baling. If hay is to be sold for shipment, it is compressed into bales of from 100 to 200 pounds. The ordinary bale averages about 100 pounds in weight. Hay in the stack or mow occupies from 350 to 500 cubic feet to the ton, depending very largely on the height of the stack, the kind of hay, and the length of time it has settled. Baled hay occupies from 100 to 150 cubic feet to the ton. Baling presses are of various kinds, and the pressure is applied in various ways. The power for pressing is generally supplied by a sweep drawn by horses, though a steam or gasoline engine may be substituted. A bale of hay is ordinarily about 16 by 18 by 40 inches, though both smaller and larger bales are made. The bale is bound with wire. Baling is not generally done until some weeks or months after the hay crop is harvested, usually during the winter when there is little other farm work.

356. Measuring Hay. As has previously been stated, a ton of hay occupies from 350 to 500 cubic feet. The vol-

ume of a mow can usually be figured quite readily, but it is much more difficult to estimate the contents of a stack. Numerous rules[1] have been proposed, but none of them is very accurate, while they all involve considerable figuring. The number of cubic feet in a ton of hay varies so greatly with the kind of hay, the length of time it has stood in the stack, and the height of the stack, that it is very difficult to get a rule which will fit all conditions. As a usual thing, the rules are more favorable to the buyer than to the seller, as they underestimate rather than overestimate the number of tons in the stack or mow. The most satisfactory method of selling hay, wherever possible, is by weight.

357. Market Classes of Hay. The standard hay on all eastern markets is timothy. Prices of other classes depend largely on the price of timothy and the quantity of its different grades available. Rules for United States grades for timothy, clover, timothy and clover mixed, mixed grass, and timothy and grass mixed hay were made public by the Bureau of Agricultural Economics early in 1923. Under these rules,

(1) *Timothy hay* must not contain more than 5 per cent of clover and 5 per cent of other grasses and legumes.
(2) *Clover hay* includes clover hay containing not more than 10 per cent of timothy and not more than 5 per cent of other grasses and legumes.
(3) *Timothy and clover mixed hay* includes all mixtures of clover and timothy containing more than 5 per cent but less than 90 per cent of clover and not more than 5 per cent of grasses and legumes other than timothy and clover.
(4) *Mixed grass hay* includes all mixtures of other grasses containing not more than 10 per cent of timothy and not more than 5 per cent of clover and other legumes.
(5) *Timothy and grass mixed hay* includes all mixtures of timothy and other grasses containing more than 5 per cent but less than 90 per cent of other grasses and not more than 5 per cent of clover and other legumes.

Classes three and five each contain four subclasses according to their composition. Numerical grades are also provided for each of the classes and subclasses, according to the condition of the hay, the stage at which it was cut, etc.

[1]For methods of determining the contents of hay in mows, ricks, and stacks see Agricultural Arithmetic by Shutts and Weir.

LABORATORY AND FIELD EXERCISES

An afternoon spent in visiting some of the hay mows, feed stores, or hay stacks in the neighborhood and studying the different types of hay, their quality and other characteristics, may be made very instructive. In the late spring or early summer, a visit might also be made to several hay meadows to study the grasses of which they are composed, the prevalence of weeds, and other factors which influence the quality of the product.

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838. Harvesting Hay with the Sweep Rake.
943. Haymaking.
956. Curing Hay on Trucks.
977. Hay Caps.
987. Labor-saving Practices in Haymaking.
1009. How to Use Haystackers in the East and South to Save Labor.
1049. Baling Hay.

CHAPTER XIII

PASTURES

358. The Importance of Pastures. The acreage of improved farm lands, according to the Census of 1920, was about 503,000,000 acres. Of this, something like 125,000,000 acres was pasture land, more than was devoted to any one harvested crop, considerably exceeding corn. The total area in range, mountain, and improved pasture land perhaps considerably exceeds one billion acres, though this figure is necessarily a very rough estimate (Section 325). It is impossible to estimate accurately the annual value of this pasture, but there is no doubt that it is greater than that of any of the harvested crops. A valuation of $1.50 an acre for the annual product of this land would aggregate as much as the annual value of the corn crop in normal times.

359. The Essentials of a Good Pasture. A good pasture should start into growth early in the season and should continue to produce feed till late in the fall. The growth of grasses should be fine rather than coarse, and the product of the pasture should be both palatable and nutritious. The yield should be abundant in order to furnish profitable returns. The plants which compose it should form a close turf which is not readily injured by tramping or close grazing.

360. The Formation of a Pasture. In the making of a pasture, about the same care is required as in the making of a meadow, though it is not so necessary to have the ground smooth and level. The plants which go into the making of a pasture should be as carefully chosen, and it is as important to have good seed, free from weeds and other impurities. Weeds materially reduce the value of a pasture, by occupying space which should be available for better plants, by

causing stock to leave the grasses which grow near them, and sometimes by actual injury to the stock or some portion of their products. Thus wild barley is injurious, as the beards cause soreness of the mouths and jaws of stock which eat the mature heads; weeds which produce burs injure the wool of sheep, making it more difficult to clean for market and reducing its market value; weeds with a strong odor, like the wild onion, affect the quality of milk and butter; and some weeds are poisonous to stock.

In the more thickly settled portions of the United States, the pastures are usually meadows which have become more or less unproductive, or low lands which are not adapted to the production of harvested crops. The general practice is to harvest one or two crops of hay from a meadow and then pasture it for a year or more before breaking it up for harvested crops. The objection to this plan is that the plants which make the best hay, usually timothy and red clover, are not particularly good pasture plants. While the plan is fairly satisfactory for a year or two, something else must be used if a permanent pasture is desired.

If a pasture is to be started which is to be more or less permanent, some grasses should be included in the mixture which will give quick returns, and others which will come on later and continue to produce pasturage in later years. It is not usually advisable to turn stock on a new pasture until the sod has become firmly established, usually during the second season of its growth. More seed should be sown for making a pasture than for a meadow.

361. Important Pasture Plants. The most important pasture plants of the region from Virginia northward to the Canadian boundary and westward to Missouri, Iowa, and Minnesota are Kentucky blue grass and white clover. These two plants come in on old meadows and in pastures almost spontaneously, and it is seldom necessary to sow them. If a mixture is sown especially for use as pasture, some seed

of each of these plants should be included, but the quantity need not be large unless the location is one where they are not common. Brome grass is also a good pasture plant in this section, and is much relished by stock. Its range of usefulness extends westward into the dry sections of Nebraska and the Dakotas. Its use is restricted, because it is difficult to obtain seed free from quack grass. In the South, Bermuda grass is the great pasture plant, though lespedeza, or Japan clover, is also important. In the Great Plains and Rocky Mountain states, the native grasses make up practically all the pastures, and for the most part are more hardy and nutritious than any introduced plants. Alfalfa is used as pasture in a limited way. In various portions of the country, annual pasture plants are sown to some extent.

362. Improving a Native Pasture. A native pasture, especially in the Eastern and Central states, may often be materially improved by proper treatment and care. Where the ground is rough and there are many hummocks, the use of the disk and smoothing harrows will help to level it and aid in the production of a better stand and more uniform growth. Brush pastures may be improved by removing all or a part of the brush by clearing, firing or pasturing with goats. The latter is perhaps the most economical method, as the goats will clear out the brush and at the same time bring in some return. Disking or harrowing pastures to loosen the surface soil, and then sowing small quantities of seed of good pasture plants such as Kentucky blue grass or white clover, will increase the productiveness of native pastures. Clipping with the mower to prevent weeds from seeding is also a good practice.

363. The Management of Pastures. In the popular mind, pastures need no care or management. All that is necessary is to turn the stock on in the spring, and the pastures will take care of themselves. If a particularly unfavorable season follows, or if the number of stock is too great for

the pasture, it may be necessary in August or September to supplement it with feed from outside, or the stock may be turned on the grain stubble or the meadows to pick whatever growth may be there. In some instances this may be a wise practice, but in general it does not seem to be, as the young seeding or the meadow may be damaged more than the stock will be benefited. It is desirable to have rather more pasture than the stock will utilize in a favorable season, or to be able to supplement the permanent pasture with annual plants on which stock may be turned or which may be cut for feeding green. Rotation grazing is sometimes recommended. By this plan, two pastures are maintained on one of which stock grazes for three or four weeks while the other is allowed to grow; then, when the first pasture becomes rather short, the stock is turned into the second and the first is allowed to recuperate. Good pasturage is thus furnished with no more land than would be required for a single pasture which would give less satisfactory service.

364. Renovating Old Pastures. The pastures of the Northeastern and North Central states are usually in part the low, wet lands of the farm which cannot profitably be brought under cultivation. The grasses which grow on this land are not usually so palatable or nutritious as those which thrive on the higher, better-drained land which is usually devoted to harvested crops. One of the first and best means of renovating or improving pastures is to provide thorough drainage. Underdrainage with tile is usually the most satisfactory and permanent method of removing surplus water from the land. When this extra supply of water is removed, air can penetrate the soil, and better kinds of grasses will grow on it. Clovers and grasses often thrive on well-drained land which would not grow there before the drainage was supplied. In many other districts beside those mentioned, drainage is one of the prime factors in improving pasture lands.

The best pastures, those on which white clover and Kentucky blue grass thrive, contain an abundance of lime. All the legumes and many of the grasses grow best where there is plenty of lime. Another step, then, in renovating pastures, is to supply lime, particularly to those which have recently been underdrained. The lime can best be added by scattering finely ground limestone over the pasture early in the spring at the rate of two tons to the acre. Lime may also be applied in the ordinary commercial form, air-slaked, at the rate of one ton to the acre, but this is usually more expensive than the ground limestone. Soils on which blue grass and the clovers grow freely do not need lime, as their presence indicates an abundance of this element.

Disking and harrowing old pastures will often aid in inducing new growth by loosening the surface soil and breaking up a sodbound condition which may have resulted from years of continuous trampling by stock. If seed of good pasture grasses is sown at this time, the growth of the pasture will be still further improved. While much of the manure is returned to the land when it is pastured, the addition of more manure will cause a more luxuriant growth of grass. The use of commercial fertilizers, particularly those which are rich in phosphorus, such as ground bone, is sometimes advisable.

Range pastures which have become scanty from overpasturing may be greatly improved by pasturing lightly for a year or two, allowing the native grasses to mature and reseed. There is no better or more efficient means of improving range pastures than this. Location of the pastures so as to allow the stock to graze on one for a time and then on another, will result in the production of more pasturage from the acreage than if the entire area is grazed continuously. This rotation allows the formation of some seed from time to time and thus aids in the renewal of the stand of useful grasses. It is seldom practical to sow grass

seed on these pastures, because the acreage is so large, and it is often difficult to obtain seed of the native grasses which compose them. The cultivated grasses of which seed can be obtained cheaply usually do not grow so well under range conditions as the native kinds.

LABORATORY AND FIELD EXERCISES

1. Visits to pastures in the neighborhood, with careful studies of the plants of which they are composed, the prevalence of weeds, and such other points as appear to be important, may be made with profit. The best time to make these studies is late in the spring or early in the fall.

2. Make parallel lists of as many things as you can think of that contribute to a good pasture and what things should be avoided. In a third column list the ways in which good pasture is useful.

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CHAPTER XIV

THE GRASSES

365. What the Grasses Are. In much of the preceding discussion of forage crops, the term "grasses" has been used in the ordinary sense of common farm usage, as including all hay and pasture plants, whether they are true grasses, legumes, or a mixture of both classes of plants. In this and the succeeding chapters the term will be used in its more limited sense, as referring only to the true grasses, the members of the *Gramineae*, or grass family, excluding from it the legumes, such as clover and alfalfa. The true grasses are among our most common plants. The number of species is very great, especially in tropical countries; several hundred are native to the United States. In temperate regions, the number of individual plants of the grasses is much greater proportionally than the number of species, large areas often being covered with a solid mat or turf of one or more species of grass. The grass family is the most important natural group of plants. It includes not only the pasture and meadow plants to which the term is commonly applied, but also the cereals, which supply a very large part of the food of men and animals. Among the more important of the forage grasses in the United States are timothy, Kentucky blue grass, redtop, orchard grass, Bermuda grass, Johnson grass, brome grass, and the native wheat grasses.

366. General Characters. Most of the grasses are comparatively short, herbaceous annuals or perennials, though a few, such as the bamboos of the tropical regions, assume shrub or tree forms. The stems are generally hollow; the nodes, or joints, are always solid. This construction of the stem allows the plant to stand considerable strain from

wind and rain without injury. The base of the leaf forms a sheath around the stem, which further strengthens it; the sheath is usually split to the base on the side opposite the blade. A thin, hard ring, called the ligule, forms the junction of the blade and the sheath, clasping the stem, or culm, and acting as a guard against the entrance of rain or dust to the inside of the sheath.

The flowers are borne in spikes or panicles, made up of spikelets of two or more bracts, or scales. They consist of from one to three very small scales, from one to six stamens, and a one-celled ovary, usually with two styles. The flowers may, however, be imperfect, as in the case of the tassel flowers of corn, which have no pistils. The stigmas are hairy or plume-like, and the anthers are attached at or near their middles to the filaments, so that they swing freely in every breeze. The fruit is a caryopsis, the seed or grain being enclosed in a membrane which adheres closely to it.

367. Differences. The grasses, though they have many characters in common, are quite variable. In height, they vary from a few inches, as in the case of many of our native prairie grasses, to several feet, as in corn and sorghum, while some of the bamboos grow to the height of large trees. The stems may be hollow, as in wheat or oats, or filled with pith, as in corn. A large proportion of the leaves may be produced at or near the base of the stem, making the grass valuable for pasture, or many of the leaves may be borne on upright stems, the plant then being suitable for hay. The flowers may be perfect, as in wheat; monœcious, as in corn; or diœcious, as in the buffalo grass of the western prairies. They may be borne in close spikes, as in timothy; in loose spikes, as in wheat or rye; or in panicles, as in oats or red-top. The plants may be annuals, as oats; winter annuals, as winter wheat; or perennials, as timothy, brome grass or blue grass. The habit of growth may vary greatly, from the erect form of timothy to the creeping habit of buffalo grass

and the bent grasses. The leaves may be numerous at the base of the stem and sparing above, or they may be small and scanty at the base and more numerous along the stem. The roots may be bulbous, as in timothy, or fibrous, as in the annual species and many of the perennial ones.

368. Why the Grasses Are Important. The grasses are of great importance in our agriculture; for they supply, in addition to the cereal grains, a very large part of the forage which is fed to domestic animals. This forage may be in the form of green herbage, either as pasture or for soiling; preserved green herbage, or silage; or dried herbage, as hay, straw, or fodder. A feature of the grasses which makes them valuable pasture plants is the location of the growing point of the leaf. This is near the base, so that the tip may be grazed or clipped off several times and the leaf still continue to grow. The forage grasses add variety to the rotation, supplying crops which may be used as meadows or pastures, or short-season crops such as millet, which may be used to occupy the land when an earlier-planted crop fails. The perennial varieties add a mass of vegetable matter to the soil. They thus improve its physical condition and their decay increases the yield of annual crops which follow. They also form a cover which prevents the loss of fertility by washing and other means of erosion.

369. Comparative Value of Different Species. The various meadow and pasture grasses differ little so far as the feeding value of their products is concerned. They contain about the same quantities of the important food elements, and these elements are about as digestible in one grass or hay as in another. There is naturally some difference in this respect among the many species, but there is likely to be as much variation between samples of any one of the important grasses when grown under different soil and climatic conditions or when cut at different stages of growth. There is a very decided variation also in the digestibility of

the same grass when cut at different stages for hay, the maximum of digestible food material usually being present at about the time the grass is in bloom or a little later.

While there is comparatively little difference in food value among the grasses, there is a great variation in palatability. Thus, Kentucky blue grass and brome grass are among our most palatable pasture grasses, while timothy makes hay which ranks high in this regard. Redtop is less palatable as pasture than Kentucky blue grass, and less as hay than timothy. Velvet grass, which contains as much food material as timothy, is not eaten by stock on account of the numerous hairs on the stems and leaves. Other grasses are unpalatable for other reasons. Different animals vary somewhat as to their choice of the grasses, so that some grasses that are highly palatable to cattle, for instance, may be less so to sheep. The soil and the proportion of the different elements of plant food which it contains also seem to have some influence on palatability.

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CHAPTER XV

PERENNIAL GRASSES

TIMOTHY

370. Origin. Timothy, *Phleum pratense*, is a native of Europe. Its cultivation in this country dates from about 1700. Timothy Hansen first grew this grass in Maryland, where it was known as Timothy's grass, and later as timothy. There has been little change in timothy since it was first cultivated, and only in the last few years have attempts been made to improve it or to separate it into varieties. Even now, it is not possible to purchase seed of any distinct variety of timothy, though there is great variation among the plants. The same statement may be made with equal truth regarding all the other forage grasses and most of the leguminous forage plants. In fact, many of them are little more than plants brought in from the wild, with no effort at improvement. There is much to be accomplished in the breeding of forage crops for special purposes, and great increases in yields of hay or pasture may be confidently expected from careful work of this kind.

371. Description. Timothy is a rather deep-rooting perennial grass, with stems, or culms, ranging from 6 or 8 inches to 6 feet high. The usual height is from 2½ to 4 feet. The culms are usually straight, but they may be bent or prostrate at the base. The lower node of the culm is enlarged, forming a sort of bulb, a character peculiar to this plant among the grasses. The culm leaves are much more numerous than the basal leaves, making the plant valuable for hay. The leaves are from 3 to 10 inches long, and from a quarter to a half inch wide. The flowers are borne in a long, close spike, usually cylindrical in form, from one and a half

to six inches in length and a quarter to a third of an inch in diameter. This spike is made up of many one-flowered spikelets. The seed is about one twelfth of an inch long, silvery gray in color, and usually loosely enclosed in the palea and flowering glume. It is easily removed from them in threshing and cleaning, however, and many of the seeds are commonly without a covering.

Figure 99.—A head of timothy, the most common tame grass of the United States.

372. Importance. In the Northeastern and North Central states, timothy is the most important meadow grass, and it is also largely used as pasture. It is of more or less importance all over the country except in the extreme South. No other grass compares with it in importance as a hay grass. Other kinds of hay are sold to some extent, but timothy is the standard. Out of a total area of 96,000,000 acres devoted to the production of hay and other forage in the United States in 1919, according to the Census reports, timothy alone was grown on 10,941,000 acres, and timothy and clover mixed on 19,349,000 acres. The only other class of hay and forage which compared at all with timothy in acreage was the combination of all wild, salt, and prairie grasses, which totaled 17,126,000 acres. The production of timothy hay amounted to 12,799,000 tons; of timothy and clover mixed, 24,743,000 tons; and of wild, salt, and prairie grasses, 15,631,000 tons. The estimated average value per ton in the United States in 1921 was $14.31.

373. Soils and Fertilizers. Timothy grows best on clay loam soils which are retentive of moisture, though it thrives on quite a variety of soils. It grows better in moist climates then in dry ones, and on fertile loams than on sandy soils. It does not grow well on very acid soils, redtop being a much better grass for such locations. The liberal use of stable manure will greatly increase the yield of timothy, while the plowing under of a leguminous crop before sowing, or the use of nitrogenous fertilizers also produces a heavier growth. In fact, some benefit is derived from the nitrogen stored in the soil by leguminous crops, such as clover, which grow with the timothy. Phosphate fertilizer is also productive of a good response.

Figure 100.—Seeds of timothy; *a*, with husk, enlarged; *b*, husk removed, enlarged; *c*, natural size.

374. Seed and Seeding. Timothy seed weighs from 42 to 50 pounds to the bushel, according to its cleanness from hulls. The legal weight in most states is 45 pounds. The usual rate of seeding is from 8 to 12 pounds to the acre, though 15 pounds is sometimes sown. When sown with clover, 7 to 10 pounds of timothy is sown with from 5 to 8 pounds of clover. Good, clean seed of a high percentage of germination should be used. Timothy seed is less subject to adulteration than the seed of many of the other grasses and clovers. Redtop, orchard grass, and other grass seeds are sometimes found in it, but usually in small quantities only. The seed is best sown with a broadcast seeder of the wheelbarrow type, though any of the common methods are generally satisfactory. A light harrowing after seeding will

cover the seed to a sufficient depth. In the winter wheat region, timothy is generally sown in the fall with that grain; farther north, it is sown in the spring with spring grain. When sown with grain, a special seeding attachment on the drill is sometimes used. Of recent years, July and August seeding without a nurse crop is in favor in some sections. As the seed is small, it should not be covered too deeply; a half inch is usually sufficient except in dry seasons.

375. Care of the Meadow. The habit of growth of timothy makes it particularly adapted to use as a hay grass. The meadow should not be pastured if the largest yields of hay are desired. The bulbs produced at the base of the culms are pulled up and eaten by stock, particularly during dry seasons when the growth of the grass is slow. These bulbs are also injured by the trampling of stock, so that very frequently, especially on new meadows, more is lost in damage to the succeeding crop of hay than is gained from the use of the pasture. In dry, hot weather, timothy should be cut with rather long stubble to avoid injury to the bulbs. The application of a top-dressing of stable manure in the spring or after the hay crop has been removed will greatly increase succeeding crops. Best results will be obtained from the use of this manure if it is scattered evenly over the meadow with a manure spreader.

376. Making Hay. Timothy hay is most readily eaten by cattle if it is cut when in bloom; horses prefer it if cut a few days after it goes out of bloom. As the quantity of dry matter produced on an acre increases up to the time the seed begins to ripen, it is probable that the larger yield of food material can be obtained by late rather than by early cutting. When a large acreage is to be harvested, cutting should begin when the plants come into blossom, in order to complete the work before the seed is ripe, for the stems become dry and woody and many of the leaves are lost after the dough stage is passed.

Timothy is usually ready to cut for hay in July, when the best conditions are presented for hay making. The plants cure readily and there is ordinarily little loss from injury by rain or dew. Little or no extra labor is required in the curing of the hay. It seldom needs to be turned with the tedder or put into cocks for curing, practically as good results being obtained when it is cured in the swath and hauled immediately to the barn or stack. A few hours are usually ample to cure the hay sufficiently for storing.

377. Value of the Hay. The prominence of timothy as a hay grass is due largely to the ease with which it can be cured, the certainty of getting a catch, the yields of hay it produces, and the cheapness of the seed. It is not particularly high in feeding value, though the fact that it can be fed with little waste and that all classes of animals eat it readily makes it a general favorite on the market. Timothy hay usually contains about 6.2 per cent of protein, 45 per cent of carbohydrates, 2.5 per cent of fat, and 29.9 per cent of crude fiber. Only about half this food material is ordinarily digestible. Timothy is somewhat lower in protein than most of the other grasses, but is about equal to them in other food materials. (Section 330).

378. Pasturing. Although timothy is not adapted to use as a pasture grass, and though meadows of it are often seriously injured for hay production by pasturing, this grass is often used for pasture purposes. It is rather a common practice to cut hay from a timothy and clover meadow for one or two seasons and then to pasture it for a year or more before breaking up the sod to plant some annual crop. While more pasturage could be obtained from any one of several other crops, this practice is a convenient one and probably will continue to prevail. Where the meadow land is to be pastured for a year or more, it is well to add small quantities of seed of some of the more permanent pasture plants, such as Kentucky blue grass, brome grass, and white

clover. These will not make enough growth to be very noticeable in the hay during the first year or two, but they will become firmly established by the time it is desired to use the land as pasture, and will furnish better and more permanent pasture than timothy and clover without them.

379. Harvesting the Seed Crop. As timothy usually makes but little second growth, it is necessary to use the first crop of the season as the seed crop. It is allowed to ripen and is cut with the grain binder, shocked, and handled in every way similar to a grain crop. The usual yield is from 3 to 5 bushels of seed to the acre. Timothy which is grown for seed should be free from weeds and from mixtures of other grasses. The price of the seed varies somewhat from season to season, but it is almost always possible to sow an acre of timothy at less cost than an acre of any other grass. This reason probably accounts for the fact that timothy is so generally sown.

KENTUCKY BLUE GRASS

380. Origin and Description. Kentucky blue grass, *Poa pratensis*, is either a native of the United States from Pennsylvania west to the Mississippi River, or it was introduced from Europe at a very early date. It is also called June grass, wire grass, and spear grass. It is now commonly found as far south as Tennessee and as far west as eastern Nebraska. It is a rather shallow-rooted grass, but makes a close, even sod, and one which is not easily injured by trampling or close grazing. The culms do not grow more than 2 feet tall. The culm leaves are scanty, not more than 6 inches long and $\frac{1}{4}$ inch broad, but the basal leaves are numerous and much larger, making the plant valuable for pasture. The flowers are produced in open, spreading panicles; the spikelets are from three to five-flowered. The grain, or caryopsis, is enclosed in the flowering glume and palea. The seed, that is, the grain and its enclosing envelope

is from one tenth to one sixth of an inch in length. Canada blue grass seed, which is often used as an adulterant, is shorter, less pointed, and is generally cleaner in appearance. The legal weight of a bushel of Kentucky blue grass seed is 14 pounds, but recleaned seed will often weigh 25 pounds or more to the bushel. The seed ripens in June, hence the name June grass.

Figure 101.—A panicle of Kentucky blue grass.

381. Related Plants. Other species of *Poa* are of some importance as pasture or meadow grasses in limited sections of the country, particularly in New York and New England. Canada blue grass, *Poa compressa*, is of some value as a pasture grass in some sections of eastern Canada, New York, and New England. It grows on poorer, heavier clay soils than Kentucky blue grass and largely takes the place of that grass in such locations. Where Kentucky blue grass will thrive, it is to be preferred to Canada blue grass, but in certain locations the latter is superior. The seed is frequently used as an adulterant of Kentucky blue grass. The main differences

in the appearance of the two grasses are that the stems of Kentucky blue grass are round, while those of Canada blue grass are flattened or compressed; the leaves of the latter are shorter and less numerous, and the panicles are less spreading. Other related grasses are wood meadow grass, *Poa nemoralis*, and fowl meadow grass, *Poa flava*. Neither of these is of much importance, though they are grown to some extent in limited areas.

Figure 102.—Seeds of (*a*) Kentucky blue grass; and (*b*) Canada blue grass. The Kentucky blue grass seeds are broadest in the center and pointed; the Canada blue grass seeds are broadest at one end and blunt.

382. Importance. In the region from Virginia north to the Canadian border and west to eastern Kansas and Nebraska, Kentucky blue grass is the most important pasture grass. It is of particular value in this region wherever there is a noticeable quantity of lime in the soil, as this element seems specially necessary for its best growth. In the mountain valleys of Virginia and West Virginia, and quite generally over much of Kentucky, this grass thrives as nowhere else, though in the limestone regions of other states it makes a very vigorous, nutritious growth. With white clover, it makes up a very large part of our pastures. It is sown comparatively little, but seeds itself in old meadows and pastures, gradually replacing the shorter-lived grasses. It is also the most important lawn grass over this area.

383. Soils and Fertilizers. Though Kentucky blue grass grows best on lime soils, it will thrive on well-drained loam and loamy clay soils of the region mentioned. It will not grow on as heavy clay soils as timothy or redtop, nor

will it do well on sandy land. Since the root system is shallow, it is not adapted to dry sections nor to dry locations. It grows better under shade than many of the other grasses, and is particularly suited to open woodland pastures.

Blue grass pastures may be improved by spreading barnyard manure over them in the fall or early winter. Nitrogen may be applied in the spring after the grass has started to grow, and fall and spring dressings of phosphates and potash are beneficial.

384. Seeding. The germination of the seed is frequently low, so that heavy seeding is necessary. Seed should not be purchased until a germination test has been made. When the grass is sown alone for immediate results, as in the case of lawns, as much as 40 pounds may be sown to the acre. If sown in a mixture with other grasses, some of which will make a quick growth which in the course of a few years will be largely replaced by blue grass, from 10 to 12 pounds will be sufficient. On account of its slowness in occupying the land and making adequate returns, Kentucky blue grass is seldom sown alone for pasture. It is either sown in a mixture or is not sown at all, the natural growth of the plant being depended on to occupy the land after it has been pastured for a few years. Even when seeded, it does not make much of a showing for three or four years and then continues to improve for several years thereafter. Best results are obtained from sowing late in the fall or early in the spring, either with or without a nurse crop.

385. Pasturing. Kentucky blue grass begins to grow early in the spring and continues its growth till late in the fall, but it does not grow well in hot, dry weather. For this reason, it needs to be supplemented to some extent during July and August. It is well to provide some extra feed for stock during these months, in the way of silage or an annual pasture or soiling crop. Blue grass is one of our most nutritious and palatable pasture grasses. Cattle prefer it

to timothy or redtop, but will eat brome grass in preference to it. No special care is needed by pastures made up of white clover and Kentucky blue grass. On land to which they are adapted, these plants will naturally improve from year to year, as most of the fertility is returned to the soil in the manure, and the clover increases the supply of nitrogen.

Figure 103.—Panicle of Canada blue grass. Contrast it with the open, spreading panicle of Kentucky blue grass in Figure 101.

386. Care of Lawns. Thorough preparation of the soil and thick seeding are necessary to get immediate results in lawns and to keep down weeds. No better lawn can be made in our Northern states than one composed of blue grass and white clover. Frequent clipping only serves to improve it. If a good stand is obtained, there will be little trouble from weeds, as there will be no room for them. Lawns should not be clipped too closely or too frequently in hot, dry weather, for the roots are likely to "burn out" from exposure to the sun. The land should be kept rich by the addition of manure or commercial fertilizers, as the fertility is rapidly removed in the clippings. The lawn should be allowed to go into the winter with a good growth of grass.

387. Harvesting Blue Grass Seed. Most of the seed of Kentucky blue grass is produced in a small area near Lexington. The seed is stripped from the heads by horse machines as soon as the panicles begin to turn yellow, gen-

erally about the second week in June. It is then piled in windrows 3 or 4 feet deep to cure, and is stirred thoroughly every day to keep it from heating. It is cured in about ten days, when it is cleaned and prepared for market. A good yield of seed as it is ordinarily cleaned is from 125 to 200 pounds to the acre. When the seed is cleaned to weigh 24 pounds or more to the bushel, the yield seldom exceeds 75 or 100 pounds.

Figure 104.—Redtop, a good grass for wet lands.

REDTOP

388. Origin and Description. Redtop, *Agrostis alba*, is a native of the United States, growing wild over a large portion of the country. The plant does not root deeply, but makes a firm, close sod, for rootstocks are produced in large numbers. It is valuable to prevent washing, and is not injured by trampling. The culms grow from 1 to 3 feet tall. They are often prostrate or recumbent at the base and root freely at the nodes where they come in contact with the soil. The basal and culm leaves are both quite numerous. The flowers are borne in an open, branching panicle which contains many one-flowered spikelets. The grass may be distinguished from Kentucky blue grass, which it resembles to some extent, by its one-flowered spikelets, later flowering, and the reddish or purplish color of the glumes.

It comes into flower about six weeks later than blue grass. The grain, which is only about one twenty-fifth of an inch long, is enclosed in the flowering glume, which is about one and one half times as long as the grain. The seed weighs about 12 pounds to the bushel before it is separated from the outer glumes; but recleaned seed may weigh as much as 36 pounds to the bushel.

389. Related Plants. A variety of redtop called creeping bent, *Agrostis alba vulgaris*, is grown to some extent in the Eastern states. It makes a finer, more slender growth than the ordinary redtop which is grown for hay, grows closer to the ground, and is better adapted for use in pastures and lawns. There are all gradations in form between creeping bent and redtop. Another closely related grass which is grown in lawns, on heavy clay soils, and in places where Kentucky blue grass does not grow well, is Rhode Island bent, *Agrostis canina*, a small form with a creeping habit. Neither of these grasses is of any value for hay production.

390. Importance. Redtop probably ranks next to timothy in importance as a hay grass over the region where timothy is grown. Its range, however, is wider than that of either timothy or blue grass, and it is most important where those grasses are sparingly grown. It thrives in New England, as far south as the northern end of the Gulf states, and on wet lands to the Pacific Coast. It grows on soils and in locations where timothy will not grow, and produces good yields of hay. The hay is about equal to timothy in feeding value, though it is not as palatable and is not in general favor. As a pasture grass, it is not well liked by stock, but it forms a sod more quickly than Kentucky blue grass, stands pasturing well, and yields an abundance of succulent feed. It is not generally sown except on soils that are too heavy, wet, or acid for timothy or blue grass to thrive. Redtop is objectionable in timothy meadows because it lowers the market value of the timothy hay.

391. Soils. Redtop will grow on a wide range of soils, though it does best in moist locations. On poor, undrained, or acid soils it has no superior. It produces a thick sod and adds much vegetable matter to the soil, so that it is of great value in building up poor clay land.

392. Seeding. The rate of seeding depends on the quality of the seed and whether it is grown alone or in a mixture. When recleaned seed is sown, from 12 to 15 pounds to the acre is sufficient when sown alone, or 6 to 8 pounds when sown with other grasses. Redtop is commonly mixed with timothy and alsike clover. The seed is sown in the same manner as timothy seed, but care must be taken not to cover it too deeply. Redtop seed is cut and threshed in the same manner as timothy seed. Most of the redtop seed is produced in southern Illinois.

ORCHARD GRASS

393. Origin and Description. Orchard grass, *Dactylis glomerata*, is a native of Europe, but is now found quite generally, though sparingly, throughout the United States except in the semiarid sections. It is rather more deeply rooted than timothy, the roots often penetrating to a depth of at least 2 feet. The plant grows in tufts, or bunches, and does not spread by creeping rootstocks. The culms are from 2 to 3 feet tall. The culm leaves are rather scanty, but are sometimes as much as 2 feet in length, and are broader than the leaves of most other grasses. The flowers are produced in June, about the same time as those of red clover. They are borne in a one-sided panicle, the spikelets being in dense clusters and containing three or four flowers. The grain is enclosed in the flowering glume, and is about one tenth of an inch long, while the flowering glume is one sixth of an inch or more in length.

394. Importance. Orchard grass is not commonly grown in this country except along the southern border of the

timothy region. In Virginia, North Carolina, Tennessee, Kentucky, and Arkansas, it is quite a prominent hay grass. It is also grown to some extent along the Pacific Coast. It produces a rather light yield of hay, while its tendency to crowd out other grasses and yet grow in bunches which do not fully occupy the ground makes it of doubtful worth where timothy will succeed. Its habit of maturing with red clover makes it of value for growing in mixtures with that legume. It will thrive in drier and shadier locations than redtop, and is of value in open woodland pastures. Orchard grass grows best on fertile, well-drained soils. It stands drought better than timothy, though it requires rather more moisture for its best development than that grass.

Figure 105.—Orchard grass, a hay grass of value in some localities.

395. Seeding. The seed of orchard grass weighs from 14 to 22 pounds to the bushel, according to its freedom from chaff. It is usually high in germination. It is sown in the same manner as timothy, though seeding by hand is the common practice when it is sown alone. The rate of seeding when grown for hay is about 35 pounds to the acre; when sown in mixtures, orchard grass makes up only a small part of the mixture, not more than 6 or 8 pounds being used.

Most of the seed is produced in a small section in the vicinity of Louisville. The crop is cut with a binder as soon as the heads turn light yellow, and the bundles are set up in small shocks to cure. When cured, in about two or three weeks, the seed is threshed with an ordinary threshing machine which has been provided with special screens.

396. Utilization. When grown for hay, orchard grass should be cut when it is in flower, for it rapidly decreases in palatability and food value after that time. The yield of hay is fairly good, and the hay, if cut at the right time, is valuable for feeding. It is seldom or never found on the market, as only small quantities are produced; but, where it is known, it is well regarded. Orchard grass produces an abundance of basal leaves early in the spring, so that it is valuable for early pasture. As it does not form a close turf, it does not stand pasturing as well as blue grass or even timothy. It lasts only three or four years when closely grazed.

Figure 106.—Bermuda grass.

BERMUDA GRASS

397. Origin and Description. Bermuda grass, *Cynodon dactylon*, was introduced into southern United States from the West Indies about two hundred years ago. It is a native of tropical and semitropical countries throughout the world. It is a low-growing grass which spreads by means of running stems both above and below the surface of the soil, forming a thick sod which is not easily injured by grazing, tramping, or clipping. The culms grow from 6 inches to 2 feet high, the latter height being reached only under the most favorable conditions. Though the culms bear few leaves, the numerous running stems are leafy, and the total quantity

of herbage which is produced is large. The flowers are borne in one-flowered spikelets in one-sided spikes, the culms producing from three to five of these spikes. The seed seldom matures in the United States, most of that which is sown being imported from Australia. Bermuda grass can not be grown successfully north of Virginia, Tennessee, Arkansas, and Oklahoma.

398. Cultivation. Bermuda grass will grow on almost any soil, though it makes a stronger and more vigorous growth on fertile loam than on any other type. It requires a liberal supply of water for its best growth and is not particularly resistant to long droughts. Unlike blue grass, however, it continues to grow during the hottest months of summer, even though droughts occur. As the seed is scarce and high in price, new fields are usually started from small pieces of sod. The sod is plowed just beneath the surface, not more than 2 or 3 inches deep, and the strips are then cut or broken into small pieces. These soon take root when planted and the running stems form a solid turf by the end of the season. In making lawns, it is customary to set these pieces of sod about a foot apart each way in well-prepared soil. In field culture, the land need not be so carefully prepared and the sods may be placed at greater intervals. If they are dropped in furrows 18 inches to 2 feet apart each way and covered by plowing the furrows shut or by dragging, they will soon start into growth and will completely cover the ground in a year. The best time to do this planting is in the spring after danger of frost is past. Hay meadows are improved by plowing or disking every few years and then harrowing down level again, for they are likely to become sodbound and unproductive if left undisturbed.

399. Uses. Bermuda grass is to the South what Kentucky blue grass is to the North, the most important pasture grass. It is perhaps not quite so nutritious as blue grass, but it produces an abundance of pasture throughout the

summer months and is far superior to any other southern pasture grass. Its principal faults are that it is slow in starting into growth in the spring and is easily killed by frost in the fall. Bermuda pasture, however, may be supplemented during the fall and spring months by sowing bur clover and rescue grass seed on the Bermuda sod in the early fall. These plants start into growth about the time the Bermuda grass ceases, and are at their best while it is dormant. They have practically completed their growth in the spring when Bermuda grass again becomes green. Where weather conditions are favorable this combination will furnish pasture practically throughout the year.

Bermuda grass is unsurpassed as a lawn grass in the South, though its late start in the spring and its dead appearance during the winter are objectionable. It is a profitable hay grass only on the better class of soils. On moist, fertile loams it will produce three or four cuttings of hay during the season. The yield of the separate cuttings is not heavy, but the total yield for the season compares favorably with the best northern hay grasses, and the hay is of good quality. Cutting should not be delayed too long, as the stems soon become wiry and unpalatable. As Bermuda grass will grow on light sand, on clay embankments, and on various other soils, and as it soon forms a thick turf, it is one of the best soil-binding grasses we have. It is useful in preventing sands from blowing and banks and rough fields from washing.

400. Eradication. A grass which grows as freely from running stems and is so vigorous is naturally somewhat difficult to eradicate, unless its habits are well understood. Except in a few localities in the extreme southern part of the United States, however, it does not produce seed, and so the problem is somewhat simplified. The sod may be killed by shallow plowing, not more than 2 inches deep, either in hot, dry weather in summer or just before a cold spell in winter.

In the first case, it dries out, and, in the second, it is killed by frost. As this grass will not grow in shade, it is easily killed by planting the field to an annual crop which will make a dense growth, as oats, sorghum, or cowpeas. Thorough plowing and good preparation, so as to insure a quick, vigorous growth of the planted crop, are necessary. Sorghum is perhaps one of the best smother crops, as it grows rapidly and makes a dense shade if planted thickly.

JOHNSON GRASS

401. Origin and Description. Johnson grass, *Andropogon halepensis*, is a native of southern Europe and Asia which is now common throughout the Southern states. It is a strong, vigorous-growing grass with large underground stolons, by which it spreads rapidly. It produces culms from 4 to 7 feet high, with numerous leaves 1 foot or more long and ½ to 1 inch wide. The flowers are borne in panicles, resembling those of sorghum, to which it is closely related. In fact, the entire plant except the perennial underground stems closely resembles a small plant of sorghum. The spikelets are in pairs at the nodes or in threes at the ends of the branches, only one of these spikelets containing a perfect flower. The grain is free from the glumes and is similar in appearance to sorghum seed. The plant seeds freely in all the Southern states and, as it spreads rapidly by both the stolons and the seeds, it is generally regarded one of the worst weeds of that section.

Another species of this genus is *Sorghum halepense*, a tall, coarse annual. Different varieties of this are cultivated for their saccharine juice or for forage.

402. Importance. While Johnson grass is a bad weed, it is also one of the best southern hay plants. It will grow on a wide range of soils and in all locations, thriving where there is an abundance of water, yet enduring drought well. It does not grow during a drought, but starts at once into

growth when rains come. It yields two or three good crops of hay during the season, which, if cut at the proper time, are palatable and nutritious. It is of some value as a pasture crop, though the pasture is of short duration, because the grass does not stand grazing well. Like other grasses with strong stolons, it produces larger yields of pasture or hay if the sod is broken every two or three years. The growth of the plant is confined almost entirely to the South Atlantic and Gulf states, though it is also found to some extent in California. It is not a troublesome weed where the ground ordinarily freezes to a depth of 6 inches or more.

403. Eradication. To eradicate Johnson grass, it is necessary to prevent it from producing seed and to guard against the introduction of seed to the field by hay, manure, or any other carrier. The easiest method of eradicating it is to pasture the field for a year or two, when the roots will all be close to the surface. Then, if the sod is broken late in the fall very shallow, not more than 3 or 4 inches, so that these roots are just turned over, many of them will be killed by frost. In the spring, the land should be worked frequently enough with the disk harrow to prevent all top growth. About the first of June, it should be planted to cotton or some other crop which can be given thorough cultivation, to prevent top growth from the few Johnson grass roots which remain, or some rank-growing crop like cowpeas may be sown to smother out the grass. Another method which is recommended is to plow the land thoroughly in the spring and cultivate it at intervals during the spring and summer, thus smothering the roots by preventing them from producing top growth. By this method, the use of the land is lost for a year. Thorough cultivation and a good rotation will most effectively keep Johnson grass in check, as they will any other weed, and it is an open question whether the southern farmer will not yet find that Johnson grass is a very useful plant and one which he has little reason to fear.

BROME GRASS

404. Origin and Description. Brome grass, *Bromus inermis*, is a native of Europe, from which country it was introduced into the United States at a comparatively recent date. It is variously know as Russian brome, smooth brome grass, and awnless brome grass. It is a deep-rooting, stoloniferous grass, with an abundance of root leaves and a good supply of culm leaves. The culms are erect, from 2½ to 4 feet tall, bearing a spreading panicle from 6 to 10 inches long. The spikelets are about 1 inch long, one fourth as broad, and contain several flowers. The seeds are three eighths to one half inch long, and are awnless. The grain, or caryopsis, is about one fourth of an inch in length, and is brown in color.

405. Related Plants. Cheat, or chess, *Bromus secalinus*, is an annual grass which is a common weed in grain fields, particularly in winter wheat and other winter grains. It makes such a vigorous growth in fields of winter grain where the stand is thin as to give rise to the somewhat common belief that "wheat turns to cheat." The grass is of little value for hay. Rescue grass, or Schrader's brome grass, *Bromus unioloides*, is of some value in the South as a winter pasture grass (Section 399). There are numerous other species of Bromus in various sections of the United States, but none of them are of apparent value.

406. Importance. Brome grass is of such recent introduction into this country that its value is not yet well understood. It seems to be unquestionably the best tame pasture grass for the Great Plains region and the Pacific Northwest, and it is of more or less value throughout the North Central and Northeastern states. It will probably be many years, however, before it replaces Kentucky blue grass to any extent in the Northeastern states as a pasture grass, or timothy as a hay grass. It does not thrive in the South and should not be sown farther south than central Kansas, except at

high elevations. Its numerous deep roots enable it to withstand drought better than any of our other cultivated grasses, which explains its value in the Great Plains and Intermountain districts. It has been cultivated for many centuries in southern and central Russia, in a climate very similar to our Great Plains region.

Figure 107. — Brome grass. Note the running rootstocks.

407. Seeding and Cultivation. The method of seeding is not different from that of timothy. It does much better on loam or clay soils than on those of a sandy nature. It grows fairly well on sandy soils, however, when once established, the difficulty being to prevent injury from blowing sands until a sod is formed. The usual rate of seeding is from 15 to 20 pounds to the acre when sown alone; when sown in mixtures, 6 to 10 pounds is sufficient. Spring seeding is most commonly practiced, though the grass may be sown in the fall with winter wheat, if conditions are favorable. The seed crop is cut with the binder and is shocked and threshed like any grain crop. Yields of from 400 to 500 pounds of seed to the acre are frequently obtained. The stubble may be cut for hay, as most of the leaves are near the base of the stalk and are left by the binder.

In permanent brome grass meadow, the sodbound condition which is likely to develop may be prevented by thorough disking without plowing at intervals of a year or two. Pastures will also be improved by disking. There is some complaint of difficulty in eradicating brome grass when it is desired to plant the land to a new crop, but this is largely

due to poor plowing and indifferent cultivation. Turning the sod completely over so that none of it is exposed to the surface, followed by the growth of a cultivated crop, will usually be effective in preventing the growth of this grass.

408. Uses. As previously stated, the best use of brome grass is for the production of pasturage in the Great Plains and Rocky Mountain states. It is useful there also as a hay grass, particularly for the first two years after seeding, for it produces an abundance of hay until it becomes sodbound. It then makes a good growth of root leaves, so that it is valuable for pasture, but throws up few flowering stems. Farther east, it is perhaps better as a pasture than as a hay grass. It is particularly recommended in the Central states for planting with alfalfa for pasture. It is one of the most palatable of grasses, cattle eating it in preference to blue grass. It is also of value in improving worn-out lands, as it produces a large quantity of stems and roots and adds materially to the vegetable matter in the soil. The principal difficulty in sowing brome grass is that it is not often possible to obtain seed which is free from quack grass.

MISCELLANEOUS GRASSES

409. The Wheat Grasses. The wheat grasses are of considerable value as pasture grasses throughout the northern Great Plains and the Pacific Northwest. Slender wheat grass, *Agropyron tenerum*, is grown to some extent as a hay grass in Washington and Oregon. It is particularly adapted to dry-land farming. Another native grass of this region, *Agropyron divergens*, or bunch grass, is also worthy of cultivation on the dry lands. Farther east, in the Rocky Mountain region, western wheat grass, *Agropyron occidentale*, is grown to some extent for hay production. Quack grass, *Agropyron repens*, is sometimes recommended for hay or pasture, but its numerous running rootstocks make it so difficult to eradicate that it should not be sown where any

other grass will grow. None of the other wheat grasses have this characteristic, and they may be sown without fear that they will become pests.

410. The Fescues. Meadow fescue, *Festuca pratensis*, and tall fescue, *Festuca pratensis elatior*, are grown in certain limited areas as hay grasses. In the timothy region, they cannot compete with that grass, for they do not yield as well and the seed is more expensive. Meadow fescue is grown quite commonly in northeastern Kansas, while both tall and meadow fescue are grown in eastern Washington and northern Idaho. These grasses are often recommended for sowing in meadow and pasture mixtures, but they do not seem to have any definite place in this country. In England and quite generally throughout Europe, they are among the most valuable grasses.

411. The Rye Grasses. English rye grass, *Lolium perenne*, and its near relative, Italian rye grass, *Lolium italicum*, are among the most popular and important grasses in Europe, but they have never come into favor in the United States. They are grown to some extent on the Pacific Coast, but elsewhere they are little known. They do not yield heavily, but the herbage they produce is so palatable and nutritious that they appear to be worthy of more extended trial as meadow grasses where the rainfall is abundant.

Table XVII. Composition of important grasses.

	DRY			GREEN		
	Digestible Nutrients in 100 pounds			Digestible Nutrients in 100 pounds		
	Crude protein	Carbo-hydrates	Fat	Crude protein	Carbo-hydrates	Fat
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Timothy	.30	42.8	1.2	1.5	19.3	0.6
Kentucky blue grass	4.7	43.5	1.5	2.3	14.8	0.6
Redtop	4.6	45.9	1.2	1.9	20.0	0.6
Bermuda grass	3.7	37.9	0.8	1.4	17.0	0.5
Johnson grass	2.9	45.0	1.0	1.2	14.7	0.5
Brome grass	5.0	44.2	0.9	2.9	15.0	0.2

LABORATORY AND FIELD EXERCISES

As many of the important perennial grasses as possible should be studied in the field or in the laboratory. If studied in the field, their characteristics should be carefully noted, particularly those that make them of importance agriculturally. Among these may be mentioned habits of growth, leafiness, seed habits, and turf-forming habits. Descriptions of the roots, stems, leaves, inflorescence, and seeds of the important grasses of the neighborhood should be prepared. If fresh specimens are not available, each student should be provided with a dried plant which has previously been prepared by the instructor.

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945. Eradication of Bermuda Grass.
990. Timothy.

CHAPTER XVI

ANNUAL FORAGE GRASSES

412. Introduction. Several annual grasses are quite generally grown as forage crops, while in some sections large acreages of the cereals are cut for hay. In addition, a large part of the straw and stover which is a by-product of grain growing is fed to stock. The principal annual plants of the grass family which are grown for forage are the millets, the sorghums, corn, oats, wheat, and barley. The Census figures for 1919 show that 5,675,000 acres of small grains were cut for hay, producing 5,463,000 tons; that the forage and grain sorghums were grown on 4,747,000 acres, producing 7,913,000 tons; and that 14,503,000 acres of corn were cut for forage, producing 17,794,000 tons. Also more than 4,000,000 acres of silage crops, mostly corn, were reported. The acreage of grains cut for hay in 1919 was abnormally large in 1919. Extreme drouth in the northern Great Plains resulted in the cutting for hay of many fields sown for grain.

THE SORGHUMS

413. Origin and Description. Sorghum, *Andropogon sorghum*, is a native of Africa and southern Asia. The forage sorghums are closely related to the grain sorghums (Section 306) and to broomcorn (Section 312), for all these plants have been developed from the same parent stock. They differ from the other members of this group in having abundant sweet juice, while the pith of the grain sorghums and of broomcorn is dry or only slightly juicy. The plant grows from 5 to 10 or more feet tall, with numerous broad leaves. The flowers are borne in a terminal panicle, varying in size and form with the variety. The seeds are red or

reddish yellow in color, protruding somewhat from between the dark red or black glumes.

414. Varieties. The principal variety of sorghum grown in the North is Amber, an early maturing, comparatively

Figure 108.—Sorghum grown in rows for forage.

small sort with an open, spreading panicle, shining black glumes, and reddish-yellow seeds. The seeds are almost entirely included within the glumes, so that the apparent color of the head is black. The Orange, a somewhat later variety with lighter-colored glumes and a more compact panicle, is less grown now than formerly. In the South, the most popular and productive variety is Sumac or Redtop, with a compact head, red seeds, and very short dark red or black glumes. The red seeds protrude from between the glumes, so that the head appears to be dark red in color. Gooseneck, a variety with large heads borne on a recurved peduncle, so

that the head is drooping instead of erect, has been widely recommended for sirup production in the South. It is late in maturing and is inferior to Sumac for the production of forage.

415. Importance. The sweet sorghums are grown quite generally for forage in the South and Southwest and to a less extent in other portions of the country. In the Central states, corn is the principal coarse forage crop, and sorghum occupies a minor place, though it is grown in a limited way. No accurate figures on the total acreage devoted to the production of sorghum for forage are obtainable, but in Kansas, where the crop is perhaps more important than in any other state, 500,000 acres are grown annually. It is quite probable that not less than two million acres of sorghum are grown in the United States every year.

Figure 109.—The compact panicle of Sumac sorghum, a popular variety in the South.

416. Culture. The methods of growing sorghum for forage are like the methods of growing corn for fodder or for silage, except that the sorghums are always planted in drills rather than in hills. The crop grows well on a wide range of soils, though it does best on those of more than average fertility. The plant has a vigorous root system, which enables it to use quick-acting fertilizers to good advantage.

The seed may be sown with the corn planter, using special plates, or with the grain drill, using all or only a part of the holes. When grown in rows and cultivated, the crop

is cut with the corn binder and handled in every way like corn. When sown in close rows, the plants make a fine growth which can be cured readily into hay. The rate of seeding in rows wide apart is from 8 to 20 pounds to the acre; when sown with a grain drill and not cultivated, 50 or 75 pounds of seed is required; while for broadcast seeding for hay, as occasionally practiced, 75 to 100 pounds is necessary. The more common method is to sow in wide drills and cultivate like corn. The seed should not be planted till after corn planting is finished, since it will germinate only in warm weather. In some sections, cowpeas or soy beans are planted with sorghum for hay or for silage, and millet is occasionally sown with it for hay production. The methods of handling for fodder and for silage are not different from those in common use with the corn crop.

417. Uses. The principal use of sorghum is as a coarse forage crop to take the place of corn in sections where the climate is too dry for the successful production of that crop. The yield of forage produced by sorghum in the South, even where the rainfall is abundant, is usually larger than that produced by corn, and the prevailing opinion is that it can be cured more readily. The feeding value of sorghum fodder is not as high as that of corn fodder which is well-eared, but is higher than that of corn stover, and the sorghum is more palatable. In the North, sorghum is more often used as a soiling crop than as a dry fodder. It is readily eaten by all kinds of stock, and is valuable during the late summer and early fall months for supplementing blue grass pastures, which are usually short at that time.

Sorghum is used to some extent as silage, though the silage is not so good as that which is made from well-matured corn. It is, however, succulent and palatable, and when supplemented with good hay and cottonseed meal or some other concentrate, it is an excellent feed for dairy cows and other classes of stock during the winter months. It is also a

valuable annual pasture crop, supplying an abundance of feed for cattle, sheep, and hogs. Cattle should be pastured on it rather sparingly at first, for there is some danger from poisoning, particularly if the growth has been stunted from drought or frost. There is no danger from feeding sorghum fodder, as the poisonous principle seems to disappear in curing. Another use of sorghum is in clearing the land of weeds. For this purpose it should be sown in close rows. As the growth of the crop is slow at first, the land should be harrowed once or twice in the direction of the rows about the time the sorghum comes up, in order to check the weeds and give it a chance. If the land is thus harrowed, the crop will soon start into rapid growth and make a dense shade which is effective in smothering out all other plants.

Figure 110.—The spreading panicle of Amber sorghum, the best early variety for the North.

418. Sorghum Sirup. When first introduced, sorghum was grown only for the production of sirup and great hopes were entertained that it could also be used for the economical production of sugar. It is possible to make sugar of good quality from sorghum juice, but the process is too ex-

pensive to make it commercially profitable. The production of sorghum sirup has decreased rapidly in recent years, owing to the manufacture of glucose and other sirups. In Kansas, where 500,000 acres of forage sorghum are grown annually, only 13,000 acres are used for sirup production.

SUDAN GRASS

419. Sudan grass is an annual sorghum similar in appearance to Johnson grass, but which has fibrous roots instead of thick, fleshy perennial rootstocks. It is an annual which has most of the good qualities of Johnson grass as a producer of large quantities of fine, nutritious hay without the objectionable feature of being difficult to eradicate when it is no longer wanted. It was introduced by the Department of Agriculture from Sudan in 1909, and immediately came into popular favor, so that it is now grown extensively in the southern half of the United States, particularly in the drier sections.

420. Description. Sudan grass when sown broadcast or in drills for hay usually grows from 3 to 5 feet high, with stems slightly smaller than a lead pencil. When grown in cultivated rows the stems are taller and larger, sometimes reaching a height of 8 to 9 feet. The plant differs from Johnson grass principally in having broader and more numerous leaves, thus making it a better hay plant, and in the character of its roots, as previously mentioned.

421. Adaptation. Sudan grass may be grown successfully for hay almost anywhere in the southern and central United States, but most valuable in the southern Great Plains, where its drought-resistance and quick growth make it an excellent hay crop. It is also valuable for hay in the Southern states generally, except in Florida and the sandy sections along the coast, where other grasses succeed better. In the irrigated sections of the Southwest and California it is second only to alfalfa as a hay crop, while in the central

United States it is an excellent substitute for millet as a catch crop for late seeding.

422. Culture. Sudan grass grows best in a firm seed bed. It is usually sown on spring plowing which has been well fined and packed by thorough harrowing. Seeding should be delayed till the soil is thoroughly warm; for, like other sorghums, Sudan grass does not grow well in cool weather. As a general rule, sowing at or just after corn-planting time will give good results. In humid sections, the best quality of hay is produced by sowing 15 to 25 pounds of seed to the acre broadcast or with the ordinary grain drill. In the Great Plains, however, sowing 2 to 6 pounds of seed in rows sufficiently far apart to allow cultivation is much safer. Sowing in rows is also advisable wherever seed production is desired.

423. Uses. This grass is most useful for hay production, though it may be cut and fed green or made into silage. The best quality of hay is produced if cut when in full bloom or just passing out of bloom, but the yield from second and later crops will be larger if the first crop is cut before full bloom is reached. In the South, as many as three or four crops may be cut in a season, particularly if the rainfall is abundant. The hay cures readily and is nutritious. On account of its fineness and leafiness it is more palatable than sorghum hay, and has replaced sorghum to a considerable extent as a hay crop. If cowpeas or some other legume is sown with the Sudan grass, the yield and feeding value of the hay are increased.

THE FOXTAIL MILLETS

424. Origin and Description. The term "millet," as already noted (Section 321), is applied to a number of annual grasses, even the sorghums being known by this name in some countries. In the present discussion it is applied particularly to what is known as foxtail millet, *Setaria italica*. This plant has long been cultivated in China and other por-

tions of Asia, where it is used as food grain as well as forage. It is probable that the original type is a native of southeastern Asia, though some botanists hold the opinion that all the varieties have been developed from the common foxtail, *Setaria viridis*, which grows wild generally throughout the North Temperate zone. The foxtail millets are annual plants with fibrous roots and slender stems, usually growing from 3 to 4 feet high. The inflorescence is a close spike, from 4 to 8 inches long. The spikelets are one-flowered, with bristles at the base, which are usually purplish. The grain threshes free from the chaff and is usually yellow or purple.

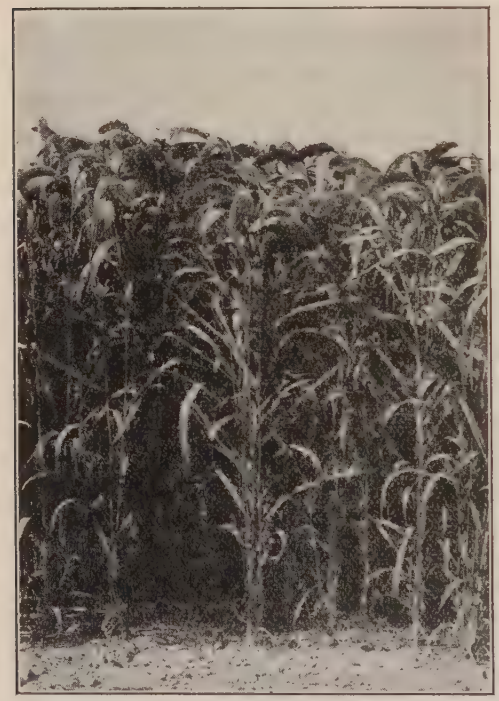

Figure 111.—German millet.

425. Varieties. The principal varieties of foxtail millet are the Common, the Hungarian, and the German. Common millet is the earliest of the three in maturing. The heads are rather loose at the base, but more compact toward the top, about 6 inches long, nodding, green in color, turning to yellowish brown when ripe. The seeds are large, yellow,

and oval. Hungarian millet is later in maturing, with shorter, erect, compact, dark purple heads. The leaves are narrower and darker green than those of common millet, and the plant produces rather less hay. The seeds are purple, but there are usually some yellow, partially matured grains. German millet does not stool as freely as the other two varieties, is later in maturing, and the growth is ranker and coarser. It yields well, but the stems are stiff and woody and the hay is less palatable than that from either Common or Hungarian. The heads are 6 to 8 inches long, broader than those of Common millet, and usually nodding. The seeds are small and round, and yellow or golden in color.

426. Importance. The millets are quick-growing plants which are grown more generally as a catch crop than for any other purpose. They do not grow well until the hot weather of summer, but if sown in June or July they will make a hay crop in six or eight weeks. They are usually sown where some earlier-planted crop has failed, as where fall-sown grain has winterkilled, or where corn has not germinated or has been destroyed by insects or rodents. As they are decidedly drought-resistant, they grow well in dry seasons or in regions of slight rainfall. The area sown to millet in the United States, was not reported in the 1920 Census.

427. Culture. Millet should not be sown till the weather is warm, not earlier than the middle of June in the Northern states, and in May and June in the South. Millet grows well on a variety of soils, but succeeds better on sandy loam than on heavy clays. As the seed is small, the ground should be well prepared. The plant has abundant feeding roots and will grow fairly well on poor soil. Like other forage crops, however, it makes a much more abundant growth on fertile land and responds readily to applications of manures and fertilizers. The seed is usually sown broadcast and harrowed in, though it may be sown with the grain drill. The rate of seeding for grain production is from 1 to 1½ pecks to

the acre; for hay, from 2 to 4 pecks are sown. The seed weighs 50 pounds to the bushel.

The crop is ready to cut for hay in from six to ten weeks from seeding, depending on the variety, the season, and the fertility of the soil. The best hay can be obtained if the crop is cut about the time the plants begin to bloom. If the seed is allowed to form, there is some decrease in palatability, and the hay may be actually injurious to horses. The hay is slower in curing than timothy hay, for the growth is usually rank and full of moisture. When grown for seed production, the crop should be cut before it is fully ripe or there will be some loss from shattering. It may be harvested with the grain binder and shocked and threshed like other grain. Twenty bushels of seed to the acre is a fair yield.

428. Uses. The foxtail millets are largely grown as emergency forage crops to supplement the usual hay and pasture supply. The hay is useful for feeding to all kinds of animals and is as palatable and nutritious as that made from most of the other grasses. Best results may be obtained when it does not make up the entire forage ration of the animals, but is fed with clover, alfalfa, or other hay. It should be fed with caution to horses; for, if fed in quantity, it is likely to cause serious disorders of the kidneys. Foxtail millet is also useful for soiling and pasture purposes, being available within a few weeks from seeding. The seed is not generally used for feeding except to poultry, though, where it is produced in quantity, good results have been obtained from feeding it to hogs, cattle, and sheep. It is better to grind the seed before feeding to hogs and cattle.

OTHER MILLETS

429. Broomcorn Millet. This class of millet is usually grown for the grain rather than for forage, as the stems are stiff and hairy and the hay is not eaten readily by stock. They have already been discussed (Section 322).

430. Barnyard Millet. Barnyard millet, *Echinochloa crus-galli*, is the common barnyard grass, which is occasionally sown for forage. It is a weed everywhere in damp, rich soils. A variety of it from Japan has been widely advertised by certain seedsmen as a very prolific forage crop, under the name of "billion dollar grass." It grows best on wet lands, and on rich soil makes a heavy growth of hay or green fodder. The stems are rather coarse and the crop is slower in maturing than the foxtail millets, which are generally preferred.

Figure 112.—Barnyard grass, or cocksfoot.

431. Pearl Millet. Pearl, or cat-tail, millet, *Pennisetum spicatum*, is a coarse annual grass which is grown mostly as a soiling crop in a very limited way on rich land in the South. It grows from 6 to 10 feet high, producing a long, compact spike similar in appearance to the common cat-tail of the swamps, hence one of the common names. It suckers freely, and will produce two or three crops in a season if cut for soiling before it produces heads. The young growth is readily eaten by stock, but it soon becomes woody and is of little value for forage. It has never become popular, and has no advantages over sorghum as a soiling and fodder crop. It is not adapted to the North.

THE SMALL GRAINS

432. According to the Census of 1920, there were 5,675,000 acres of grains cut green for hay, with a production of 5,463,000 tons. This total is largely made up of the cereals, though it also includes some of the annual legumes, such as cowpeas and soy beans. About one half of this area is in

the Pacific states, where wheat and barley are the principal annual hay crops. Most of the rest is in the North, where oats or a mixture of peas and oats are grown for hay.

433. Corn. A large part of the corn crop, particularly in the Northern states, is used for silage, soiling, fodder, or stover. The production and uses of corn have been discussed.

434. Teosinte. It is a near relative of corn, but adapted only to semitropical conditions. In the South it will produce a greater yield of green fodder than any other plant. It will grow to a height of 8 or 10 feet, but should be cut when it is about 5 feet high. It will then make a second crop as heavy as the first. The seed should be planted in hills 4 or 5 feet apart each way, and the crop cultivated like corn. As it stools abundantly, 1 to 3 pounds of seed will plant an acre.

LABORATORY AND FIELD EXERCISES

1. Collect and mount specimens of all crops discussed in this chapter. Every student of agriculture should be able to identify either by the seed or by complete plants all the common varieties of the sorghums and millets.

2. Make a careful study of the results secured in the community with sorghums and millets as forage crops and as seed crops. From the experiences in the community what would be a practical recommendation concerning the value of the growth of these crops?

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1126. Sudan Grass.
509. Forage Crops for the Cotton Region.
605. Sudan Grass.
793. Foxtail Millet.

CHAPTER XVII

THE LEGUMES

435. What Legumes Are. The term "legume" was formerly applied to any plant belonging to the order *Leguminoseae*, the word being the Latin name for the kind of seed pod which is borne by practically all plants of this group. A legume in the original sense is a dry pod which opens along both edges, or sutures, as the pod of the pea or bean, but the term is now applied to any plant which belongs to this order. Modern botanists have divided the *Leguminoseae* into several families, the largest and most important of which is the *Papilionaceae*, in which are included practically all the cultivated legumes. This latter name is derived from the Latin word *papilio*, a butterfly, from the resemblance of the flower to that insect. Among the useful plants of this family are the clovers, alfalfa, the vetches, peas, beans, soy beans, cowpeas, and numerous other plants of less importance.

436. General Characters. The legumes are decidedly variable, yet they have many features in common. The leaves are alternate and are usually compound. The flowers are irregular as to size and shape of the petals, but are usually more or less butterfly-shaped. There are commonly five petals, a broad upper one known as the standard or banner, two lateral ones (the wings), and two front ones, often more or less united (the keel). The stamens are usually ten in number, often united, or nine in one group and one alone. The pistil is single and the ovary is one-celled, but may contain a number of seeds. The fruit is a legume, which splits open along both edges when mature. The seed is almost entirely filled with the cotyledons, or seed leaves, and on germination the entire seed often appears above

ground, as in the case of the bean, the seed splitting in half and forming the two cotyledons of the young plant.

437. Differences. While the legumes have many points in common, there are numerous other respects in which they differ. They may be small herbs, shrubs, vines, or trees. They may be annual, biennial, or perennial. The herbaceous plants may be erect, as alfalfa; prostrate, as white clover; trailing or climbing, as the vetches and some forms of the cowpea. The leaves may be made up of three or many leaflets; they may be palmate, all the leaflets growing from a single point, as in the clovers; or they may be pinnate, the leaflets being arranged along the midrib, as in alfalfa and the vetches. The flowers may be of many sizes, forms, and colors, and may be arranged in numerous forms. They may be in a close umbel, or head, as in the clovers, or in a spike or raceme, as in alfalfa and sweet clover. The seed pods may be long and straight, as in the pea; more or less curved, as in the bean; coiled, as in alfalfa; or of various other shapes and sizes. Though the roots are all of the same general form, consisting of a main taproot with many branches, they vary greatly in the depth to which they penetrate the soil. Some annual species, like the pea and the bean, root only 2 or 3 feet under ordinary conditions, while the perennial species reach a great depth, particularly alfalfa, which under favorable conditions may go down from 20 to 40 feet.

438. Why the Legumes Are Important. The legumes are important in our system of farming for several reasons. They supply palatable forage which is especially rich in protein, much richer than any of the grasses. They also furnish seeds which are important articles of food for man and for animals, as peas, beans, soy beans, and cowpeas. They add variety to the rotation; and, as they are seldom attacked by the same insects and diseases which trouble that other important family of crop plants, the grasses, they furnish an excellent means of combating these pests by means of a rota-

tion of crops (Section 654). On account of the deep-rooting habit of many of the plants of this family, they improve the physical condition of the soil, penetrating the lower layers and leaving channels to carry off surplus water and admit air when the roots decay. They add some available plant food to the upper layers of the soil by bringing it up from below. They materially increase the fertility and improve the physical condition of the soil by adding a large supply of organic matter. Lastly, they are very important in the rotation, because they have power, through the medium of bacteria which live on their roots, to take nitrogen from the air and leave it in the soil available for the use of other plants.

Figure 113.—Young plant of red clover, showing tubercles on the roots.

439. How the Legumes Gather Nitrogen. Bacteria and other forms of minute life often live on our useful plants as parasites and do considerable injury, as in the case of the

grain smuts and rusts, fruit rots, and other fungous diseases. In the case of the nitrifying bacteria, however, the relation toward the host plant is a helpful rather than a harmful one. If a healthy clover or pea or bean plant is dug up very carefully and the earth washed away from the roots, many little knots or bunches will be found on them. These knots, or tubercles, which vary greatly in shape and size according to the plant on which they grow, are filled with thousands of bacteria, too small to be seen without a very powerful microscope.[1] These bacteria take the nitrogen from the air and change it into a form which can be used by the plants. Nitrogen is the most expensive fertilizer to purchase; and, as the legumes add it to the soil and at the same time yield a valuable crop of hay or seed, we can see their importance.

440. Conditions Necessary for Nitrifying Bacteria. Air is one of the essentials for the growth of nitrifying bacteria. Unless the soil is in good condition to admit a plentiful supply of air, these bacteria are unable to do their work. Tillage is beneficial to them, as it stirs the soil, loosens it, and admits air. Drainage is also helpful, for a soil which is full of water cannot admit the necessary air. Few leguminous plants grow well on low, wet, sour land, though alsike clover thrives in such situations. Sour, or acid, soils are not suitable for the growth of these bacteria. This condition can be remedied by the addition of lime. The acidity of the soil can easily be tested in a general way by applying a little of the moist soil to litmus paper. If the soil turns blue litmus paper red, it is acid and needs lime. The application of half a ton or a ton of lime to the acre, or double that quantity of ground limestone, will generally correct this acidity.

441. Inoculation. Though the forms of nitrifying bacteria on the roots of our various legumes are very similar, they usually can not be transferred from one kind of plant

[1] A number of illustrations of typical forms of tubercles on leguminous and other plants will be found in the Yearbook of the Department of Agriculture for 1910, pp. 213-218.

to another. For this reason, it is sometimes necessary in introducing a new legume into a community to supply it with the proper bacteria by means of inoculation. As the bacteria are very small and increase rapidly under favorable conditions, a small quantity of them will inoculate a considerable area. One of the best methods of inoculation is to take a quantity of soil from a field on which the crop in question has been growing and scatter it on the field to which it is to be introduced. This operation is sometimes expensive, particularly if the soil has to be shipped some distance, as the transportation charges will then be heavy. Five to eight hundred pounds of inoculated soil should be applied to each acre of the new field if the inoculated soil can be obtained close at hand. If it must be shipped from a distance, from 200 to 300 pounds may be made to suffice, thus reducing the expense of transportation. This inoculated soil may be mixed with several hundred pounds of ordinary soil before it is applied, as the larger quantity can be spread more easily and evenly. It is often better to start a small plat and then use soil from it to inoculate larger fields.

Where the distance from an old field makes inoculation by soil transfer too expensive, what is known as the "pure culture" method of inoculation may be used, though it is less generally successful than the other methods. The bacteria are grown artificially in culture media, and shipped either in the dry form similar to cakes of yeast, or in tubes containing the liquid solution. Before using the powder or liquid it is put into a vessel containing water, a little sugar, and other suitable material for the growth of the bacteria. In a few days the water takes on a milky hue from the large increase in numbers of the bacteria, and it is then sprinkled on the seed or is mixed with soil and spread on the field. It is much easier to inoculate the seed, which should then be sown within a few days. As the desired bacteria are present in small numbers in most soils and are usually

present on the seed, complete inoculation is often obtained by gradually increasing their number. This is best done by mixing a small quantity of the seed of the legume desired along with the grass seed. In a few years the bacteria will have increased sufficiently to insure the success of a straight legume seeding. Special inoculation is not often necessary except for alfalfa, and is not always essential for the success of that crop. A liberal application of barnyard manure, particularly that from stock fed alfalfa hay, is very helpful and often meets all requirements.

LABORATORY AND FIELD EXERCISES

Dig up any of the common legumes carefully when they are growing rapidly during the late spring or early summer, and examine the nodules on their roots. These nodules are of quite different shapes and sizes on different plants. If they can be examined under a high-power microscope, they will prove still more interesting. It may be possible to find fields of alfalfa or some other legume where the nodules are not present and others where they are. Note the difference in growth. The instructor may provide an illustration of this kind by planting seeds of red clover or some other legume common in the neighborhood in ordinary soil in one pot, and seed which has been carefully washed to free it from nitrifying bacteria in soil that has been baked long enough to sterilize it in another pot. This should be done long enough before this lesson is reached to allow the plants several weeks' growth or, if there is sufficient time between this lesson and the close of the school year for the plants to make the necessary growth, the pupils may do the planting and watch results.

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CHAPTER XVIII

THE CLOVERS

442. Introduction. The term "clover" is applied to a large number of leguminous forage crops, but only those which belong to the genus *Trifolium* are discussed in this chapter. The *Trifolia* are leafy herbs which grow from a few inches to three feet high, with flowers in dense heads or spikes. The leaves consist of three palmately-arranged leaflets, the number of leaflets being indicated by the botanical name of the genus. This genus includes many species, the most important of which are red clover, white clover, alsike clover, and crimson clover. Closely related plants to which the common name is ordinarily applied, but which are not true clovers, such as sweet, bur, and Japan clover, are discussed elsewhere (Sections 513-519).

RED CLOVER

443. Origin and Description. Red clover is a native of Europe and western Asia, and has been cultivated only about three or four hundred years. It was first domesticated in western Europe, and was introduced into England about 1630. It has been cultivated in the United States for many years, and is now the most important leguminous crop in the Northeastern and North Central states.

The botanical name of red clover is *Trifolium pratense.* It is distinguished from other species of *Trifolium* by its red flowers and oval or globose heads. Mammoth clover, sometimes classified as *Trifolium perenne,* is very similar to it, and is usually regarded simply as a large variety of red clover. It differs from the ordinary type only in that it makes a ranker growth and matures somewhat later. Red clover is

Figure 114.—Heads of red clover at different stages.

claimed by some botanists to be a perennial, but ordinarily it is a biennial, as it seldom lives more than two years on account of numerous insects and diseases which attack it.

Numerous leafy stems are produced from a crown. These reach a height of from 1 foot to 2 feet, depending on the rainfall and the soil. Usually the taller plants do not stand erect, so that the crop seldom appears to be more than 18 inches high. The leaflets usually have a pale spot in the center. The flowers are borne in dense heads, which often contain one hundred or more individual flowers. They are similar in shape to pea flowers, but much smaller, and have a long tube. The length of the flower is about half an inch, and the width only about one sixteenth of an inch. The pods are small and membraneous, enclosing the kidney-shaped seeds, which are about one twelfth of an inch long. The seeds vary in color from yellow to purple.

444. Importance of the Crop. According to the Census report, there were 22,509,000 acres devoted to the production of clover and mixed clover and timothy in the United States in 1919. Only four of our farm crops occupied a larger area, these being corn, wheat, oats, and cotton. Of this area, however, only 3,160,000 acres were in clover alone, the remainder being used for the production of mixed hay. With the exception of small areas in other states, clover production is confined to the North Atlantic and North Central states, the region extending from Maine to Virginia and westward to the eastern portion of the Dakotas, Nebraska, and Kansas. There are also considerable areas devoted to clover in western Oregon and western Washington. Alfalfa largely replaces clover in the Rocky Mountain states, though occasionally large crops of clover are grown in valleys where alfalfa does not thrive.

The principal states in the production of clover and mixed clover and timothy are New York with 3,291,000 acres; Wisconsin, Michigan, Iowa, and Pennsylvania with

2,200,000 to 1,776,000 acres each; and Illinois, Missouri, Minnesota and Ohio next in order with more than a million acres each.

In the region north of the Ohio River and east of the Missouri, to the Atlantic Ocean, red clover is more widely grown than any other legume, and is probably sown on a larger acreage than all other legumes combined. White clover is very common in pastures over this area, but is not generally sown; for, like Kentucky blue grass, it rapidly establishes itself on fields which lie undisturbed for a few years. In the South, where it does not thrive, red clover is replaced by numerous annual legumes and to some extent by alfalfa, while in the irrigated sections alfalfa is much more commonly grown on account of the greater number of crops it produces in a season and its longer period of life.

445. The Best Soils for Red Clover. Red clover makes its best growth on a deep, fertile loam, though the soil does not need to be rich in nitrogen on account of the power of this plant, through the nitrifying bacteria, to utilize the nitrogen in the air. Like other legumes, red clover will store up little nitrogen on soils which are already well-stocked with it, but the bacteria do much more effective work on soils with a low nitrogen content. Some nitrogen is necessary to give the plants a start and allow time for the bacteria to establish themselves, but the supply need not be large. A deep soil is desirable for clover, as the root system is extensive; the roots will go down 5 or 6 feet if possible.

As clover draws rather heavily on the supply of potash and phosphorus, these elements should be present in fairly liberal quantities. In general, any soil which will grow good corn will grow clover. Wet, undrained land is not adapted to red clover. On such soils alsike clover can be grown more successfully. On poor soils the application of eight or ten loads of barnyard manure to an acre will aid materially in getting a good stand and healthy growth of red clover.

446. Preparation of the Land. Where clover is sown in the spring with grain sown the previous fall, no special preparation is possible. Where it is sown alone or at the same time as the grain, special attention should be given to the preparation of the seed bed. The surface should be fine, but the seed bed should be firm rather than loose. Clover grows best in a soil that is well settled, as fall-plowed land or disked corn or potato land. Newly plowed land should be disked or harrowed with heavy harrows to pack the lower layers before clover seed is sown on it.

Figure 115.—Seeds of red clover and common adulterants and weed seeds found in it.

447. The Kind of Seed to Use. Good clover seed is plump and of a bright color, of uniform size and free from weed seeds and other foreign matter. Bad weeds are frequently brought to the farm through clover seed. A careful examination should be made to determine that no such pests are present. Home-grown seed is much safer to use than that which is purchased, for it can be kept free

from weeds and there is no danger of introducing new and troublesome pests. New seed is not so desirable as that which is a year old, because new seed usually contains a considerable percentage of "hard seed" which will not germinate for some months after planting. No seed should be purchased until a sample has been obtained and a test of its purity and germination has been made. Too little attention is commonly given to the quality of grass and clover seed, and as a consequence large quantities of inferior seed are sold every year.

448. Sowing the Seed. The common method of getting a stand of red clover is to sow the seed in the spring on land that was sown to winter wheat the previous fall or to sow it with spring wheat, oats, or barley. When sown with winter wheat, the seed is usually scattered on the surface before the frost is out of the ground in the spring, and the subsequent freezing and thawing and the spring rains are depended on to cover it sufficiently. Some farmers delay sowing until April, when the rains alone are expected to cover the seed. A more satisfactory method is to harrow the land lightly both before and after the clover seed is sown. If the harrow is run in the same direction as the drill rows, the wheat will not be injured but may even be benefited if the season is dry, and the clover is much more certain to succeed. If the seed is to be harrowed in, it should be sown just as early as the land is in condition to work in the spring.

When sown with a spring grain crop, the seed is usually distributed by hand or with a broadcast seeder after the grain is drilled, though it may be sown with a seeder attachment to the drill. It is not customary to cover the clover to so great a depth as the grain, though on loamy and sandy soils the seed is sometimes sown in the drills with it. When this practice is followed, the drill must not be permitted to run more than 2 inches deep, and shallower seeding is desirable. The usual quantity of clover seed sown is from 8 to 12 pounds to the acre, when it is the only crop seeded.

When sown with timothy, about 8 to 10 pounds of the seed of that grass is sown with about 8 pounds of clover, the amounts of each approaching an equality.

Winter wheat is one of the best nurse crops for clover, as it makes comparatively little shade, is removed from the land early, and does not draw heavily on the moisture supply. Winter rye is also good, and winter barley is hardy enough to be used for this purpose along the southern edge of the clover belt. Next to the winter grains, spring wheat and spring barley are desirable as nurse crops. Oats draw heavily on the soil moisture and make a dense shade, hence they are less desirable for this purpose, though they are very commonly used. In some sections the practice of sowing clover in corn at the last cultivation is increasing (Figure 117). Where there is plenty of moisture, this method usually gives a good stand, but in dry seasons it is quite likely to fail. It is objectionable for the establishment of meadows, as the cornstalks or stubble will cause trouble the first season in making hay. Millet, buckwheat, and crops which make a rank growth should never be used as nurse crops.

449. Sowing without a Nurse Crop. In sections where the winters are not so severe as to make winterkilling probable, the seeding of clover in August or early September without a nurse crop is often more successful than sowing with a grain crop. The use of a nurse crop allows the production of a crop while the stand of clover is being established, and the stubble is of some protection to the young plants, particularly during the winter. The nurse crop, however, often draws so heavily on the supply of soil moisture and plant food that the clover is injured, while the sudden exposure of the tender plants to the full effects of the sun and wind in midsummer when the grain is removed is often disastrous. The loss of a crop may be avoided by preparing the land after the grain is harvested and sowing the clover not later than August 15. Sowing after that date is likely

to result in loss from winterkilling. If sown after grain or early potatoes, the land need not be plowed, but should be disked and harrowed so as to make it fine and mellow. If clover is sown alone in the spring, under favorable conditions a fair cutting of hay may be obtained that season; if sown in the late summer after some other crop is removed, a good crop should be produced the following year.

Figure 116.—A good stand of young clover in grain stubble.

450. Inoculation. In sections where red clover is commonly grown, inoculation is not usually necessary, for the soil is well stocked with the proper bacteria. In newly settled regions where it is desired to introduce clover, inoculation by means of soil from an old clover field or of pure cultures of the proper bacteria may sometimes be necessary.

451. Treatment of the Crop. Clover is seldom given any treatment from the time the seed is sown till it is cut for hay the following year. It is sometimes possible to pasture spring seeding the following fall, but close pasturing will reduce the crop the succeeding year. Cattle injure the young plants much less than sheep or hogs, because they do not

graze so closely. Clipping back the young clover and the weeds a few weeks after the nurse crop is harvested is often the most beneficial treatment which can be given. This treatment is not advisable in the North, however, unless there is time before frost for the plants to make sufficient growth to protect the roots from winter injury. A top-dressing of manure will greatly increase the yield, though, if the supply of manure is limited, it may be applied with greater profit just before breaking up the clover sod for corn.

The usual practice the second season is to cut the first crop for hay as soon as it comes into blossom, cutting the second crop either for seed or hay. Conditions are usually better for seed production at the time the second crop matures. The second growth may also be pastured, or if the land needs vegetable matter it may be plowed under to benefit the crop which follows. Better returns will be obtained, however, if this second crop is pastured or is cut and fed on the farm and the manure returned to the land. Clover alone ordinarily does not maintain a good stand after the second year unless the second crop is allowed to produce seed and this seed is harrowed in. When mixed with timothy, good meadows may be maintained for three or four years, particularly if a top-dressing of manure is given, but the hay crop during the later years will contain a large proportion of timothy.

452. Making Clover Hay. Directions have already been given for hay making (Sections 350-352). Somewhat more than ordinary care is needed to make good hay from clover or the other leguminous crops, for they cure less readily than the grasses. The best clover hay is usually obtained by cutting when a majority of the blossoms are a little past full bloom. As the leaves contain a large part of the food material in the most palatable form, they are a very valuable part of the hay. They are best retained by curing largely in the shade. The hay should be cut in the morning as soon as

the dew is off, kept loose with the tedder, and raked and put into small cocks before the leaves are dry enough to shatter. In this way most of the curing is done in the cock where

Figure 117.—A fine stand of young clover in corn. The practice of seeding clover in corn at the last cultivation is growing to be quite common in some sections.

the leaves are protected from the sun. Two or three days are necessary in good weather for the clover to cure. It is usually desirable to open the cocks to the sun and air for

a few hours before storing. The use of cock covers to protect the hay from dew and rain is generally necessary to obtain the best quality of hay. Clover should not be allowed to become too dry before it is put into the mow or stack, or the leaves will crumble and the hay will be dusty.

If the hay is stacked, rather more than ordinary care is necessary in building the stack, for clover hay does not shed water as readily as hay made from the grasses. Much valuable hay may be saved if a foundation of rails or of poor hay is put down before the stack of clover hay is started and if the stack is covered with grass hay, straw, or boards. It is a good plan to have this covering extend as far down the sides of the stack as possible to prevent loss from weathering.

Care must be taken not to put the hay into the mow or stack when it is wet with dew or rain, as spontaneous combustion may result from the heating which will take place. Even though the hay does not become hot enough to burn, it is very likely to be seriously damaged.

453. Pasturing Red Clover. Red clover is an excellent pasture plant for stock of all kinds, though it is not so good for permanent pasture as white clover. Close pasturing during the first year of its growth or early in the spring is likely to greatly reduce the quantity of hay or pasture which will be supplied during the season. Sheep or cattle are sometimes likely to bloat when first turned on clover pasture, particularly if they are hungry and the clover is damp. The stock should be well filled with other feed when turned in and be accustomed to the clover gradually.

454. Value of Clover Hay and Pasture. As clover is rich in protein, it makes an excellent part of the ration for all kinds of stock, particularly for young and growing animals, for dairy cows, and for poultry. Where clover can be grown successfully, protein can be supplied more cheaply in this form than in bran, oilmeal, or other expensive purchased feeds. Red clover contains considerably less protein than

alfalfa, but about the same quantity of the other nutrients (Section 330). It is best for pasture along with timothy.

455. Harvesting the Seed Crop. The production of seed is usually possible wherever clover can be grown successfully. Except in the extreme northern part of the clover region, it is customary to utilize the second growth for seed production, because it is more likely to produce a profitable crop. To have the seed mature in good weather and escape insect pests which may be serious a little later, the first crop is cut a few days earlier, when the second crop is to be cut for seed, than would otherwise be done. In the North, where the growing season is short, there is not time to grow a crop of hay and one of seed; so the early growth is pastured or clipped back till about the middle of June, and the plants are then allowed to bloom and produce seed. This is the practice to some extent where there is ample time for two crops to mature, as the attacks of the clover midge and other insects are averted and much larger yields of seed are obtained.

Clover seed should be cut when the heads have turned brown, and the seed is in the hard dough stage. If cut earlier, shriveled seed will result; while, if cutting is delayed, many of the heads will break off in handling. Unless an average of twenty-five or more seeds can be rubbed out of the mature heads, it will not usually pay to cut the crop for seed; it should be cut for hay instead. The seed crop should be handled as little as possible to prevent loss of the heads. The usual method is to cut with a self-rake reaper or with a mower with buncher attached. Either of these implements places the clover behind the machine where it will not be trampled by the horses on the next round. It is then put into cocks for curing, and within a week or two, if the weather is favorable, it is ready to be hulled. Clover seed is seldom stacked, for too much of the seed would be lost in the extra handling. The clover huller is quite similar to the threshing machine, but has an extra set of rasps for rubbing the

seed from the hulls. The usual yield is but 1 or 2 bushels to the acre, though 5 bushels is sometimes obtained. The usual price for clover seed is from $5 to $10 a bushel of 60 pounds, though in 1918 it sold as high as $20 a bushel.

456. Place in the Rotation. Clover occupies a prominent place in the rotation throughout the region where it is grown. It usually follows a small grain crop and precedes corn or potatoes. As has previously been stated, it is generally sown with winter wheat or with some one of the spring grains. Where corn is an important crop, the common rotation is a 3-year one of wheat, clover, corn or oats, clover, corn, though two crops of corn may be grown in succession, making a 4-year rotation. Where potatoes are largely grown, a common rotation is potatoes, oats, clover. Sometimes the clover is left for two years, or two crops of potatoes or one of potatoes and one of corn are grown, making this a 4-year instead of a 3-year rotation. In any case, clover is depended on to add vegetable matter and nitrogen to the soil. Where it is grown as often as once in three years, this element need not generally be purchased, but potash and phosphorus will have to be added either in commercial fertilizers or barnyard manure, unless the soil is very rich in these constituents. Best results are usually obtained when the manure is applied to the clover sod before breaking it up for corn.

457. Enemies of Red Clover. The most common fungous diseases which attack the clover plant are leaf spot, rust, stem rot, and root rot. These diseases seldom do serious injury to a vigorous stand, but on poor land or elsewhere under conditions where the plant does not thrive they may cause serious injury. The best remedies are to improve the condition of the soil by adding fertility or by draining, and to practice a proper rotation of crops.

Insects usually do far more damage to clover than diseases. Among the more common enemies are the clover-root-borer, the clover-leaf weevil, and the clover-flower midge.

The rootborer usually does not seriously affect the stand until the latter part of the second year, when the roots are large enough to harbor the larvae, or grubs. They then enter the roots and bore through the upper portions, greatly weakening the plants. The best remedy is to plow the land soon after the crop of hay is removed the second year, thus destroying the food of the grubs. The clover-leaf weevil sometimes destroys the leaves of the plant in the early spring; but, as new growth is soon produced, it does little serious damage. The clover-flower midge does no harm to the hay crop; but, as the eggs are laid in the heads and the grubs develop there, they feed on the young seed and prevent the production of a seed crop. Their ravages are checked if the first crop of hay is cut quite early, for the larvae will then have no opportunity to develop, and the second crop will be beyond the possibility of damage by the time the second brood appears.

A parasitic pest known as dodder is sometimes quite troublesome in clover fields. This plant begins growth about the same time as the young clover plants, and the stem soon attaches itself to the stems and leaves of the clover, coiling tightly around them. The ground stem of the dodder then dies away and the plant lives on the clover. The best preventive measure is to examine the clover seed carefully to make certain that it is free from the seeds of dodder. If it gets into the field, the entire growth of clover which contains dodder should be cut away close to the ground and burned. Great care should be taken that no pieces of dodder are left or dropped, as they will at once start into new growth.

WHITE CLOVER

458. White Clover is one of our commonest plants, appearing in pastures, lawns, roadsides, and other places which are left unbroken for two or three years. It is a shallow-rooted plant with a creeping habit of growth. It does not

grow high enough for hay production, but with Kentucky blue grass forms the best pasture combination for a large part of the country. The botanical name, *Trifolium repens*, indicates its trailing habit. The plant is perennial, with small, long-stalked leaves and small heads of white or pinkish flowers on long stems. The seeds are only about half as long as those of red clover, and are orange or yellow in color. The plant grows and blooms practically throughout the season.

Figure 118.—Alsike (1) and white clover (2). Note the differences in habit of growth and the manner in which roots are produced all along the stem of white clover. It is this character which makes it so persistent in pastures

White clover is occasionally sown in pasture mixtures at the rate of from 2 to 5 pounds to the acre, though the natural growth of this plant is generally depended on to produce a good stand in pastures. Its prostrate or trailing habit materially helps it in its spread, as the stems root at the joints and produce new plants. It is for this reason and on account of the small size of the seeds that white clover spreads so rapidly, and that such a small quantity of seed is needed to obtain a good stand. White clover is an important honey plant, and is also generally used in lawn mixtures. With blue grass it makes a close, even turf which stands frequent cutting.

The seed is produced mostly in eastern Wisconsin, where this plant is grown in a 2-year rotation with barley. The price is usually about the same as that of red clover seed.

ALSIKE CLOVER

459. Alsike Clover is intermediate in appearance between red and white clover, and is claimed by some to be a hybrid between the two species. Its botanical name, *Trifolium hybridum*, indicates such an origin, but botanists now generally agree that it is a distinct species. The plant makes a slender, upright growth, which needs support to prevent lodging, so that it does best in a mixture with some of the grasses, as timothy or brome grass. As the stems are smooth, it makes a cleaner hay than red clover. The leaves have long stalks like white clover; the leaflets are somewhat larger than those of white clover, as are also the heads of pink flowers and the yellow or green seeds. The name alsike is from the town of Syke or Alsyke in Sweden, where the plant is said to have been first cultivated. Another common name, Swedish clover, is from a similar source.

Alsike clover is particularly adapted to wet lands, where it is often substituted for red clover. It makes hay of excellent quality, but the yield is usually less than that of red clover, and only one cutting can be made during the season. It is less adapted to use in pastures than white clover. When sown in mixtures with grasses, about 4 to 6 pounds of seed is used. The hay is somewhat easier to cure than red clover hay, because the stems are smaller. The plant lives from three to five years, and is, therefore, more permanent than red clover. It will also endure cold better.

CRIMSON CLOVER

460. Crimson Clover, *Trifolium incarnatum*, is an annual clover which is sown along the southern Atlantic coast as a winter cover and green manure crop, and is also used to some

extent for the production of hay. This plant was introduced from Europe at a comparatively recent date and is not extensively grown. From Delaware southward, it makes an excellent cover crop in orchards and elsewhere. It should be seeded in July or early in August and plowed under or cut for hay when it comes into bloom the following spring. The plants, which reach a height of 3 feet on good soil, are erect in their growth. The heads are terminal, and are much longer than those of the other clovers, forming a dense spike. The bright crimson flowers are very striking in appearance. The reddish yellow or straw yellow seeds are larger than those of red clover. Twelve to twenty pounds is sown to the acre. A mixture with other seed is seldom used.

Figure 119.—Crimson clover.

Crimson clover may be sown along the Atlantic coast in August and plowed under in May in plenty of time to plant a crop of cotton or corn. It adds a large quantity of vegetable matter to the soil and also materially increases the supply of nitrogen. It is seldom used as a pasture crop, but is occasionally cut for hay. The hairy stems and leaves are somewhat objectionable, and when the hay forms a large part or all of the ration of an animal, "hair balls" are sometimes formed in the stomach, giving considerable trouble.

LABORATORY AND FIELD EXERCISES

1. Mount specimens of the different kinds of clovers, showing full root system.

2. Compare roots taken from different kinds of soils. What is the difference? Why?

3. Compare the leaves and stems. What do these have to do with the quality of hay?

4. If possible, try to grow a few clover plants on inoculated soil and a few on soil that has not been inoculated. What are the results?

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CHAPTER XIX

ALFALFA

461. Origin and History. Alfalfa has been cultivated for forage longer than any other leguminous plant. Though it is probable that both the cowpea and the soy bean were grown at an earlier date for their seeds, their first use as forage is much more recent than that of alfalfa. Alfalfa is a native of Persia and other portions of southwestern Asia, whence it was taken to Greece more than two thousand years ago. It was cultivated by the Romans, and for many centuries has been an important forage crop in southern Europe. The Spanish introduced it at a very early date into South America, Mexico, and what is now southwestern United States. It was very successful in California and elsewhere, but the earlier attempts to grow it east of the Rocky Mountains were failures. It is now known that these failures were due quite largely to the absence of the proper bacteria, but it was long thought that other soil conditions were not suitable. Finally it was successfully grown in Kansas, and since the cause of the earlier failures has been shown, and its obvious advantages are understood, it is now being grown in every state of the Union.

462. Description. Alfalfa differs from the clovers. to which it is closely related, in that the flowers are in short spikes rather than in dense heads; the pods are coiled instead of straight; and the third leaflet, instead of growing from the same point as the other two, is on a short stalk of its own, making the leaf pinnate instead of palmate. The genus to which alfalfa belongs, *Medicago*, differs from another closely related one, *Melilotus*, the sweet clovers, in that the sweet clover flowers are in long racemes and the pods are straight.

The sweet clover leaflets are arranged like those of alfalfa, and the plants are quite similar till they begin to bloom.

Alfalfa, *Medicago sativa*, differs from the other plants of the genus which are found in America in that it is perennial instead of annual, and that the flowers are usually purple, while those of the others, the medics or the bur clovers, are yellow. The numerous stems which are produced arise from a crown, growing from 15 to 24 inches long, and are erect or spreading according to their length and the thickness of the stand. The long taproot penetrates to a great depth, with many small branches or feeding roots. The leaflets vary greatly in size, but usually range from ½ to 1 inch in length and somewhat less in width. The flowers, which are slightly larger than the individual flowers of red clover, are in short racemes. They are usually violet-purple in color, though sometimes much lighter, inclining to a pale whitish or yellowish purple. The pods are in two or three coils, brown when ripe, and contain several seeds. The seeds are

Figure 120.—Alfalfa plant showing the manner in which a large number of stems are produced from one root or crown.

somewhat kidney-shaped, though the coils of the pod may compress them into other forms. They are about the same size as red clover seeds, but are much less variable in color, being quite uniformly bright olive green.

463. Varieties. The ordinary grower gives little attention to varieties of alfalfa, and few really distinct ones have been developed. One which is prominent in Minnesota, North Dokata, and other northern states on account of its hardiness is the Grimm alfalfa, introduced into Carver County, Minnesota, by Wendelin Grimm, an early German settler. Other strains of alfalfa have recently been introduced which are quite similar to the Grimm in many respects. The most noticeable difference in Grimm alfalfa from the ordinary type, in addition to its extra hardiness, is the wide variation in the color of the flowers, ranging from white through yellow and greenish to the purple of the ordinary strain. Other varieties are named largely from the localities from which they have been imported, including the Turkestan, Peruvian, and Arabian. Large quantities of seed of ordinary alfalfa have been sold as Turkestan, which was claimed to be remarkably resistant to drought and cold. The true Turkestan alfalfa does possess these qualities to some extent, but it is better than the common varieties only in limited sections in the semiarid West. Both Peruvian and Arabian alfalfa are marked by a long growing season and a lack of hardiness. They are a success only in the Southwest, as in Arizona and southern California.

464. Production in the United States. The area in alfalfa, as reported by the Census of 1920, was 8,625,000 acres, the largest acreages being in Kansas, Colorado, California, Nebraska, and Idaho, though the crop is widely grown in all the states from Nebraska and Kansas westward, including Montana, Oklahoma, and portions of Texas. While it is more naturally adapted to warmer climates, it is grown as far north as Canada and in altitudes as

high as 8,000 feet. In the irrigated portions of the Far Western states, alfalfa is the principal forage crop. Outside of this district, it is more important in Kansas, where more than 1,300,000 acres are now grown, being more than three times the combined area in clover and all the tame grasses. Its cultivation has spread in recent years to the

Figure 121.—Alfalfa seed on the left, and red clover seed on the right.

states east of the Mississippi River, and, though there is no large acreage in any state, the importance of the crop is rapidly increasing.

The reasons for the popularity of alfalfa where it can be grown are not hard to find. Once established, it lasts for years and yields from three to five cuttings of very valuable hay during the season, the total production being considerably greater than from red clover. It thrives in the South where red clover will not grow; when once established it is more drought-resistant. The feeding value of the hay is greater than that of red clover hay. When a stand of alfalfa is broken up, corn or other crops yield heavily, for the alfalfa adds a large supply of nitrogen to the soil, and the long roots improve its physical condition by making the lower layers more porous.

465. The yield of alfalfa varies greatly in different portions of the country, depending on the rainfall, the fertility

of the soil and the length of the growing season. In the South and Southwest, where four or five or more cuttings may be made in a season and there is an abundant supply of water either from rainfall or irrigation, the yield may vary from ½ ton to 2 or 3 tons to the acre at a cutting, and the total yield for the season may reach 6 or 8 tons. Where conditions are less favorable, the annual yield usually varies from 1 to 3 or 4 tons to the acre. The average yield for the entire country in 1919, as reported by the Census Bureau, was 2.19 tons to the acre. The usual growing season for a crop of hay is from 30 to 40 days, though in warm weather, with plenty of rain, the field may be ready for cutting in 25 days from the removal of the previous crop.

466. Soils and Fertilizers. The soils best adapted to alfalfa are the deep loams, in which the roots can penetrate to a considerable depth. A stiff clay subsoil which is too hard for the roots to penetrate is not suitable, while sandy land does not produce growth vigorous enough to keep down weeds. On rich loams a stand of alfalfa, when well established, will usually crowd out weeds of all kinds. Good drainage is essential, for the plants will not grow with "wet feet." Plenty of water is a necessity for the best growth of the crop, but the plant must be allowed to go after it and bring it up from the lower layers of the soil.

Although alfalfa will store nitrogen in the soil, it will not thrive on poor land. Some nitrogen must be supplied till the plants get a start and the bacteria begin their work. Good supplies of phosphorus and potash are necessary. When it is thought advisable to use acid phosphate, about 200 pounds an acre should be applied. Barnyard manure is the best fertilizer for alfalfa. If a liberal application of manure is plowed under before the alfalfa seed is sown, there will usually be no trouble in getting a stand. Lime is essential to the growth of alfalfa, particularly to the bacteria which live on its roots. Unless the soil is known to

contain a liberal supply of lime, the addition of a ton to the acre on at least a small portion of the field as an experiment is advisable. Alfalfa will not thrive on sour soil. Lime is the proper corrective.

467. Preparation of the Land. One of the greatest essentials for success in the production of alfalfa is a properly prepared seed bed. Few crops depend so much on this. As it is very desirable to have the land free from weeds before alfalfa is sown, it is usually well to have some cultivated crop precede it. In the South, this may be cowpeas, cotton, or corn, though cotton and corn are not often removed early enough to allow the seeding of alfalfa the same season. Early potatoes leave the land in excellent condition for alfalfa. A small grain crop, while not as desirable as a cultivated crop, may precede alfalfa, as it can be removed in time to allow the preparation of the land for late summer seeding.

While plowing is desirable, it is not always necessary. If the land was plowed for the preceding crop and has been kept free from trash, disking often gives as good results as plowing. When the land is plowed, the work should be done several weeks before seeding to give the soil time to settle and become firm. Alfalfa grows best in a soil that is fine and mellow on the surface, but is fairly compact beneath so that it will hold moisture well. Where alfalfa is sown on corn land in the spring, thorough disking and harrowing will put it in good shape. The same thing is true where alfalfa follows a small grain crop, particularly if the land was plowed for the small grain. On sandy land, it is well to sow the seed in grain stubble or to scatter a light top-dressing of straw over the field to protect the young plants from injury by the blowing of the soil particles.

468. Sowing the Seed. The usual method is to sow from 12 to 20 pounds of alfalfa seed to the acre without a nurse crop, sowing the seed with a broadcast seeder and covering it by a light harrowing. The heavier rate of seeding is de-

sirable in the humid districts, particularly where alfalfa is not commonly grown. Twelve to 15 pounds to the acre is quite sufficient throughout the Rocky Mountain and Pacific states. A grass seed attachment to a grain drill gives even distribution of the seed, but is a slower method than the use of some type of broadcast seeder. The seed should be covered to a depth of from ½ inch to 2 inches, depending on the soil and the rainfall. It should be covered deeper in light sandy soils than in heavy ones, and in dry sections or in dry seasons than in wet ones.

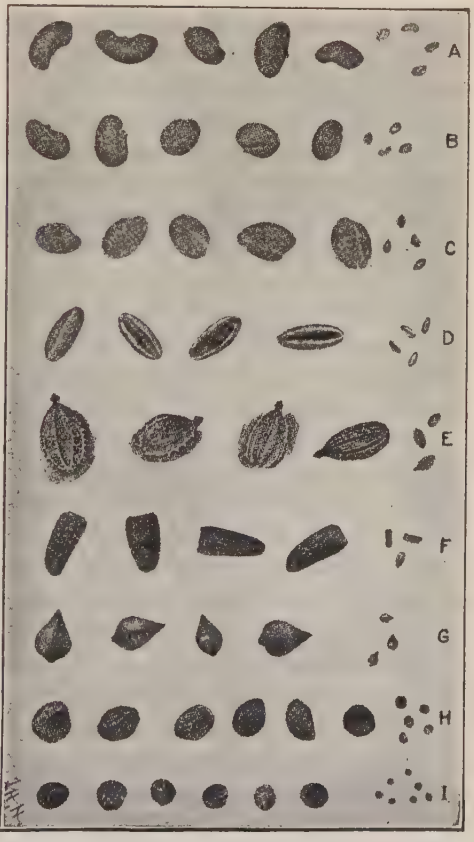

Figure 122.—Seeds of alfalfa and common impurities. Seeds at right are natural size. A, alfalfa; B, yellow trefoil; C, sweet clover; D, buckhorn; E, wild carrot; F, wild chicory; G, curled dock; H, large-seeded dodder; I, small-seeded dodder (From Farmers' Bulletin 339.)

469. Time of Seeding. Success is most often attained with alfalfa when it is sown in the summer or early fall, rather than in the spring. From the middle of June to the middle

of July is the best time to sow alfalfa in the northern states; the latter part of July or the first half of August is preferable in the central section; in the South, September is best. The proper time to sow varies to some extent from year to year, as it is desirable to get the seed into the ground when it contains plenty of moisture. If the land has been prepared some weeks in advance and has been harrowed after every shower so as to save all the rain which has fallen, there is usually no trouble from this source, except in the semiarid districts. Where the precipitation is light, spring seeding is often best, in order to take advantage of the June rains. There is usually more trouble from weeds with spring seeding, unless special treatment was given the previous year to clear the land of them.

470. Sowing with a Nurse Crop. A nurse crop is not commonly used with alfalfa, though in some sections its use is regarded as good practice. On sandy land a nurse crop may protect the young alfalfa plants from wind injury, but it should be seeded very thinly. Generally, the use of a nurse crop is more likely to result in injury than in benefit.

471. Inoculation. When alfalfa is sown for the first time in a locality, inoculation is quite often necessary to attain success. This inoculation may be by means of soil from an old alfalfa field, or by the use of pure cultures of the bacteria. The use of soil from old fields is more generally successful. As the bacterium on sweet clover is apparently the same as that on alfalfa, the inoculation of fields where this plant grows freely is not often necessary, for the bacteria transfer readily from one to the other. The bacterium from red clover will not grow on alfalfa. When a good stand of alfalfa is once obtained, it is then easy to spread the bacteria to other fields by scattering a few hundred pounds of the soil from the old fields over each acre of the new. The same result may be obtained if manure from stock which have been fed on alfalfa hay is used, while the dust blown from one

field to another often carries enough bacteria to inoculate land on which the crop has not previously been grown.

472. Treatment of New Meadows. If alfalfa is sown in the spring, it is likely to need some attention during the first season to keep down weeds. If the weeds are numerous and threaten to destroy the stand of alfalfa, the plants should be clipped back with the mower to a height of about 6 inches. If the plants begin to turn yellow, clipping will often start them into vigorous new growth. If this yellowing is due to disease, the clippings should be burned, otherwise they may be left as a mulch. If the alfalfa is not sown till late summer or early fall, no clipping or other treatment is usually necessary that year, and the following season one or more crops of hay may be cut. The field should not be pastured the first or second year, for the young crowns are quite easily destroyed. Later, when they become more firmly established, some pasturing is possible.

473. Treatment of Old Meadows. On loose soil no treatment is ordinarily given to alfalfa meadows other than an occasional harrowing. On land which is inclined to pack, disking every spring with the disks set straight so as to cut up the surface, but not to throw out the plants or cut off the crowns, will improve the growth of the crop. Disking should be done with caution where alfalfa does not thrive, for it may cause much more injury than benefit. If it seems desirable to disk the field, experiment with a small portion of it for a season before risking the entire acreage.

474. Making the Hay. The time to cut alfalfa for hay is when the young sprouts of the second growth begin to start from the crowns, which is when the plants are just coming into bloom. Cutting should not be delayed beyond this time, for the leaves of the old stems will begin to drop off, and the new growth will be considerably retarded. After the hay is cut, it should be removed from the land as soon as possible to give the new growth a chance. The growth

of succeeding crops depends in large measure on the promptness of cutting at the proper time and of removing the hay when it is cut. A little delay at each cutting may mean the loss of an entire crop in the course of the season.

The methods of curing alfalfa hay do not differ from those of curing clover hay. It is very desirable that the hay be

Figure 123.—Hay caps are useful in obtaining the best quality of hay. They prevent injury from rain and aid in saving a large proportion of the leaves of clover or alfalfa.

cured with as little loss of leaves as possible, and that it be green rather than brown when cured. This means that a large part of the curing must be done in the windrow or cock. Alfalfa should not be left in the swath exposed to the sun and wind for more than a few hours unless weather conditions make it absolutely necessary.

After the hay is cured, it may be put into the barn or stack with the ordinary hay tools. This is the usual practice in the East, but in the West it is commonly stacked with the sweep rakes or "go-devils" in common use there. With these tools, several hundred pounds of hay are gathered in bunches and brought to the stacks without the use of wagons. These stacks are usually scattered over the fields to obviate

hauling for long distances, the several cuttings of the season all being put into the same stack or group of stacks.

As alfalfa hay does not shed water readily, the stacks should be covered with grass hay or straw to prevent injury from the weather. If the hay is to be sold, it is sometimes baled in the field as it cures, particularly in the dry sections of the West, but for immediate baling it must be much drier than for stacking.

475. Harvesting the Seed. The best seed crops of alfalfa are produced only in the drier portions of the country. Alfalfa does not produce good seed freely under humid conditions, though a good quality and yield of seed can sometimes be obtained. Most of the seed which is now raised in the United States is produced in the irrigated districts of the West, though some dry-land alfalfa seed is grown. As light and air are needed for the production of seed, the best conditions are obtained by thin seeding in rows. As soon as the seed crop is removed, the land should be cultivated to start new growth. This method may also be used for the production of hay where the rainfall is insufficient to grow it by ordinary methods.

The alfalfa seed crop should be handled in about the same way as a seed crop of clover. As the seed sets best only in hot, dry weather, the second crop is usually left for seed, conditions then being more favorable than at any other season. When irrigated alfalfa is grown for seed, that particular crop is not usually irrigated. The seed crop should be cut when about three fourths of the pods are brown. If left till later, many of the earliest and best pods will drop off and be lost. The seed is usually hulled without stacking, for it should be handled as little as possible. A fair crop of seed is 3 or 4 bushels to the acre, and as the price is usually high, the seed crop is often a paying one.

476. Alfalfa in Rotations. In the sections of the country where alfalfa does not succeed particularly well or where it is

not a leading crop and more especially where weedy grasses crowd it out after a few years, the use of this crop in a 4-year or 5-year rotation is usually advisable. A good rotation for these conditions consists of oats or some other small grain, alfalfa and corn. The ground is prepared for alfalfa

Figure 124.—Cutting alfalfa for seed with the self-rake reaper. This machine is still used in some sections for harvesting grain. It deposits the crop in bunches, as shown at the right in the picture.

as soon as the small grain is removed in the summer, and the seed is sown a few weeks later. The following two to five years the alfalfa is cut for hay, and then the sod is broken for corn. From one to three crops of corn and two or three crops of small grain are grown, to be again followed by alfalfa. Numerous variations of this rotation may be devised, such as the use of a crop of early potatoes or other truck crop before seeding alfalfa, or the substitution of potatoes for corn where corn is not grown.

In some sections, it is desirable to leave a piece of land in alfalfa for a number of years. No definite rotation is then

followed, the land being left in alfalfa as long as it continues to yield profitable crops. The best success can be obtained from this system only when the supply of phosphorus and potash is maintained by the addition of fertilizers. When old alfalfa sod is broken, the land is planted to potatoes, corn, or small grain for a few years, and then reseeded to alfalfa. Larger profits would often be made if the sod were broken at shorter intervals and a regular rotation followed, as the loss from diseases and insects would be reduced.

In the cotton section, corn, cotton, and alfalfa can be worked into a good rotation, particularly if some small grain is grown. Alfalfa can be sown to best advantage in this section on land from which a grain crop has been removed. After two or three years, when it is desired to break up the stand of alfalfa, a crop of corn may be grown, followed by a crop of cotton. Winter grain may then be sown among the cotton stalks in the fall, and the alfalfa seeded the following season after the grain is removed.

477. Use of the Hay. By far the greater part of the alfalfa crop is used for hay. This hay can be fed to all kinds of stock, including even hogs and poultry. It is rich in feeding value, 11 pounds of it containing as much protein

Table XVIII. Composition of Alfalfa

	DRY			GREEN		
	Digestible Nutrients in 100 pounds			Digestible Nutrients in 100 pounds		
	Crude protein	Carbohydrates	Fat	Crude protein	Carbohydrates	Fat
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
All analyses	10.6	39.0	0.9	3.3	10.4	0.4
First cutting	9.3	39.0	0.6	.....	.....	.....
Second cutting	11.2	40.2	0.7	.....	.....	.....
Before bloom	15.4	35.5	1.6	3.5	7.5	0.3
In bloom	10.5	38.5	0.7	3.3	10.8	0.3
In seed	8.5	39.2	1.0	.....	.....	.....
Meal	10.2	38.7	0.8	.....	.....	.....
Leaves	15.8	35.1	1.3	.....	.....	.....
Stems	1.8	46.9	0.4	.....	.....	.....

as 10 pounds of bran. It contains nearly twice as much protein as clover hay and as much of the other nutrients. When fed to dairy cattle, it can largely take the place of grain or mill feeds. It produces rapid gains on beef cattle, sheep, and hogs, when fed with corn or other grain rich in carbohydrates. Growing stock of all kinds utilize alfalfa to good advantage, and it produces excellent results when fed to laying hens.

478. Alfalfa Pasture. While the stand of alfalfa is injured if it is pastured too closely, where this crop is grown in a short rotation there is little harm in pasturing it. No better pasture for hogs can be found. If it is desired to pasture the same field for several years, a large enough acreage should be provided so that it is never eaten down close. If necessary, it may be cut for hay at intervals during the season. Care should be taken to avoid bloating in first turning cattle and sheep on alfalfa pasture (Section 453).

479. Alfalfa for Soiling. Perhaps as large returns are obtained from soiling alfalfa as in any other way. It starts into growth again quickly and there is no waste in feeding. The largest yields are obtained if it is cut just when the new sprouts start from the crown, for then there is no delay in the production of the next crop.

480. Alfalfa Meal. During recent years the manufacture of meal from alfalfa hay has attained some prominence. This is simply the hay ground fine, so that stock eat the coarser stems as well as the leaves. In this form it can be fed without loss to all kinds of stock, including poultry.

481. Insect and Rodent Pests. The grasshopper is the most serious insect enemy of alfalfa in most sections. Disking the field in the very early spring is sometimes beneficial, since it exposes the young grasshoppers to the spring frosts and the attacks of birds. The use of the "hopperdozer," an implement which when drawn across the fields knocks the insects into a pan of oil, is sometimes necessary when the pests become serious. Blister beetles sometimes cause in-

jury; cutting the crop when they appear forces them to migrate. Such rodents as prairie dogs and meadow mice are destructive to stands of alfalfa in the West. These can best be dealt with by poisoning with grain or potatoes soaked in strychnine, or pouring carbon bisulphide into the burrows.

482. Diseases. Various rusts, leaf-spots, and mildews sometimes attack alfalfa, particularly when it is growing under unfavorable circumstances. About the only remedy is to mow the field, removing the diseased stems and leaves and encouraging the development of strong new growth. In Texas, a disease known as root rot is destructive to this and other taprooted plants. This can best be kept in check by growing grain or corn on the land for several years, as these plants are not affected.

483. Weeds. Numerous weeds make the growing of alfalfa rather difficult; wild barley, crabgrass, and foxtail are particularly troublesome. In the blue grass region, Kentucky blue grass is one of the worst pests with which the alfalfa grower has to contend. All these plants can be kept down to some extent by disking, but when they once gain a foothold, it is often better to break up the alfalfa sod and cultivate the land for two years before starting anew. Where these grasses are common, a short rotation is better than leaving the land in alfalfa for many years.

Alfalfa dodder, a parasitic vine, is as serious a pest as dodder in clover. The same remedies, the sowing of clean seed and the removal of all dodder plants wherever they appear, are applicable.

LABORATORY AND FIELD EXERCISES

A study of the growth of alfalfa, its root system, and the tubercles on its roots, may be made in the field, if the crop is grown in the neighborhood. At least a small plat of this plant should be grown on the school farm. Some time may well be spent in the study of alfalfa seed, to become familiar with the seed and to aid in detecting adulterants and other impurities.

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1283. How to Grow Alfalfa.

CHAPTER XX

MISCELLANEOUS LEGUMES

484. Other Useful Legumes. In addition to the clovers and alfalfa, there are other legumes which are grown in a more or less limited way for forage or for their seeds, or both. Among the plants which are grown under field conditions for both seed and forage are the cowpea, soy bean, field pea, and peanut, while the field bean is grown for the seeds alone. In districts where canning factories are located, the common garden pea is grown in large fields. Among the plants grown for forage or green manure are sweet clover, bur clover, Japan clover, the vetches, and the velvet bean.

Of these legumes, some are fully as important in districts where they are grown as are alfalfa and red clover in the regions to which they are adapted, and very largely take the place of those standard forage plants. Thus in the South, the cowpea is the most important forage plant and soil renovator. In some sections of the North a similar place is held by the field pea. Japan clover largely takes the place of white clover in southern pastures, while in Florida, Georgia, and Alabama, the velvet bean is a most important forage and green manure plant.

Still other less important leguminous plants are grown in a limited way in some portions of the country, but they are not of enough importance to require extended discussion. Among these plants may be mentioned sainfoin, Egyptian clover, beggarweed, trefoil, lupines, and horse bean.

THE COWPEA

485. Origin and Description. The cowpea, *Vigna sinensis*, is a native of China, where it has been cultivated for many

centuries. Its introduction into the southern United States dates back only a few decades. The plant, which is an annual, resembles the bean much more closely than the pea, the habit of growth and the forms of the leaves and seeds being quite similar to the garden bean. The plants vary greatly in habit, some of the varieties standing erect and reaching a height of 15 to 18 inches, while others are trailing or twining and grow several feet long. The leaflets are three in number; they vary in length from 2 to 6 inches and are nearly as wide as they are long. The greenish-yellow flowers, which are shaped like those of the pea, are borne on long stalks. The pods are several inches long, cylindrical, and contain from six to fifteen seeds. The seeds are about the size of a navy bean, though there is wide variation among the different varieties in the size of the seed as well as in the color of the seed coat.

Figure 125.—Cowpea branch with leaves, pods, and flowers.

486. Varieties. Numerous varieties of cowpeas are grown, the number of names probably reaching seventy-five or one hundred. These vary in habit of growth, shape and color of the seed, length of growing season, and in other characters. One of the most common is the Whippoorwill, a vigorous-growing, fairly erect variety with mottled reddish or chocolate-colored seeds. It is largely grown for the production of both grain and hay. The Iron has small, clay-colored seeds. The vine is an erect grower, seeds freely, and as the plants are resistant to disease, it is coming to be a popular variety. The New Era and one or two similar varieties of small-seeded, mottled peas which grow erect and mature early are grown to some extent in the

North, but are of little importance farther south where the stronger-growing, later varieties can be grown. Other more or less prominent varieties are the Black, Blackeye, Brabham, Groit, Unknown, Red Ripper, and the various Crowders, the latter name being given on account of the crowded appearance of the peas in the pod.

487. Importance. The cowpea is almost as great a factor in the agriculture of the South as clover is in that of the North or alfalfa in the West. As it grows only in warm weather and needs a rather long season to develop, it is confined largely to the Southern states, though a few early varieties are grown as far north as Michigan. The general culture of the plant does not extend north of Kansas, Kentucky or Maryland. No definite estimate of the acreage devoted to this crop can be made, but in recent years it has rapidly increased all over the South. It is used in a variety of ways, as a hay or seed crop, as a pasture crop, as a gatherer of nitrogen, and as a green manure crop to add both humus and nitrogen. It is sown alone or in combination with other crops, a common practice being to sow it with corn at the last cultivation, either in the rows or between them.

488. Soils and Fertilizers. Cowpeas will grow on almost any soil, though naturally they grow better on a fertile loam than elsewhere. Some varieties, like the Black, are particularly adapted to sandy land. Others do better on the heavier clays and clay loams. As the cowpea is a nitrogen gatherer, this element need not be supplied. A considerable quantity of food material is stored in the large seed, and the young plant is able to develop a vigorous root system before this is exhausted, which fact explains why the cowpea thrives on land that is very low in fertility. Rich land tends to produce vines at the expense of seed production. A fair supply of potash and phosphorus is necessary for the best growth of the crop, and on poor soils greatly increased yields are obtained when these elements are supplied.

489. Growing the Crop. Though the plants will grow fairly well on land that has had little attention, the stronger growth in a good seed bed pays well for the extra work of preparation. The land is usually plowed for cowpeas, though, when they follow a grain crop or a cultivated crop late in the season, the seed may be disked or cultivated in without plowing. The seed is sown broadcast, with the grain drill, or in rows far enough apart to cultivate. When grown for hay, one of the first two methods is used, while for seed production the plants are more often grown in cultivated rows. The seed should be covered to a depth of from 1½ to 2 inches. As the plants are tender, seeding should not begin till after all danger of frost is past and the weather is warm. Sowings can be made from that time up to August in the South, while along the northern limit of their cultivation seed may be sown as late as July 10 with fair prospect of a good hay crop. The usual rate of seeding is 2 to 3 pecks in rows, 4 to 5 pecks when sown with the grain drill, and 6 to 8 pecks when sown broadcast. When grown for hay, the date of planting is usually fixed so that the harvest comes in September, as weather conditions are generally more favorable for curing at that time than at any other. Cowpeas sown broadcast or with the grain drill require no further treatment till harvest. Those sown in rows are cultivated much like corn, though two or three cultivations are all that are usually necessary, for the plants soon cover the ground.

490. Making Cowpea Hay. Cowpeas should be cut for hay when one third or more of the pods are ripe. The hay will then contain the largest quantity of nutriment. If left till half or more are ripe, some of the peas are likely to shell out in handling and the leaves may begin to drop before cutting. The hay is usually cut with the mower and is left in the swath for two or three days to cure. When cut at this stage the hay cures quite rapidly, but the best hay is made if it is put up in cocks after it has partly cured in the

swath. In wet weather, frames are sometimes used to raise the hay off the ground, and admit air to all parts of the cock. After the hay is cured, it may be stacked or put in the mow in the same manner as other hay.

491. Harvesting the Seed Crop. The best crops of cowpea seed are produced when the plants are grown in rows and cultivated. The crop should not be harvested till two thirds or more of the pods are fully ripe. The pods may be picked by hand, or the entire plant may be harvested by cutting with a self-rake reaper, a bean harvester, or an ordinary mower with or without a buncher attachment. In any case, the pods and vines should be thoroughly dry before they are threshed. If the vines are harvested, the use of racks for drying is quite generally advisable to prevent the peas from molding in the cocks. After the vines are cured, they may be put in the mow or stack and threshed out as desired. The threshing may be done with a flail, with the ordinary threshing machine with part of the concaves removed, or with a special pea thresher.

492. Cowpeas as Feed for Stock. Cowpea hay may be fed to all classes of stock, but is particularly good for feeding to dairy cows, sheep, and hogs. It makes an excellent addition to the ration for beef cattle, and is also largely fed to horses in some districts. The hay, particularly if it contains a fair percentage of seed, is very rich in protein, and contains a good supply of the other food constituents. The straw from the production of cowpea seed is less valuable than cowpea hay, since it contains fewer leaves, practically no seeds, and the vines are coarser and less palatable. It does contain considerable nutriment, however, and, when fed with other material, makes good roughage. The seeds of cowpeas are usually too high in price to be fed with profit, but they are an excellent feed for stock of all kinds, including poultry. The cowpea plant makes very good pasture, though better results are usually obtained from other uses. A

field of mature cowpeas may be cheaply and profitably harvested by pasturing it off with hogs or sheep. Cattle also thrive on cowpea pasture, but should be turned in before the peas mature.

493. Use as a Soil Improver. One of the most important uses of the cowpea is in the building up of poor or worn-out

Figure 126.—Plowing under cowpeas to add vegetable matter to the soil. Note the pulverizer behind the plow to break up clods and pack the loose earth.

soils. When the entire plant is turned under, it adds large quantities of vegetable matter containing a considerable supply of nitrogen. When the stubble alone is plowed under, the vigorous roots materially improve the condition of the soil and some nitrogen is added. Practically all crops grow better after cowpeas. Largely increased yields have been obtained at all the southern experiment stations following this crop.

494. Growing with Other Crops. Cowpeas are frequently grown with other crops, including sorghum, corn,

and millet. When grown with sorghum or millet, the seed is usually sown broadcast and the crop cut for hay or for green forage. The addition of these plants makes the hay somewhat easier to cure and also increases the yield. Peas may be planted in the rows with corn and may grow along with the crop, both being cut for fodder or for silage, or they may be planted in the corn at the last cultivation. In the latter case, they are pastured off with the cornstalks after the corn is harvested, or the vines are turned under to add vegetable matter to the soil.

495. Use in Rotations. As corn and cotton are the most important crops in the region where cowpeas are most largely grown, all rotations are usually based on these two crops. A good rotation is (1) cotton; (2) corn with cowpeas sown in it; (3) winter grain sown after the corn is removed, followed the next summer by cowpeas sown on the stubble for hay or seed. Numerous variations of this rotation may be devised, but if possible a crop of cowpeas should be turned under and one harvested for hay or seed once in three years. As the seasons are long and the crops make rapid growth in warm weather, the plan of growing cowpeas after a grain crop has been harvested is entirely practicable in the South.

496. Insects and Diseases. Cowpeas are seldom injured by insects when growing, but weevils are very destructive to the seed after it is harvested. It is generally believed that they damage the seed less in the pod than when it is threshed, and so it is rather a common practice not to thresh the seed till near planting time in the spring. In threshed seed, they may be killed by fumigating in tight boxes or bins with carbon bisulphide (Section 150), or by being raised to a temperature of 130° F. in a tight room for 20 minutes.

The most troublesome diseases are root knot and wilt, which usually occur only on sandy soils along the Atlantic Coast. The best preventive measures are rotation of crops and the use of resistant varieties, such as Iron.

THE SOY BEAN

497. Origin and Description. Much that has been said regarding the cowpea applies equally well to the soy bean. This plant was introduced into the United States nearly one hundred years ago from Japan and China, where, like the cowpea, it has been cultivated for many centuries, but it has come into prominence only recently. The growth is usually erect, with stiff, hairy stems and numerous large, broad leaves. The leaves, which are borne on long stems, consist of three leaflets. The leaflets are from 2 to 3 inches long; and the width is about two thirds of the length. The flowers are small, clustered in the axils of the leaves, and are usually pale purple or lilac in color. The short, hairy pods contain two or three round or slightly flattened seeds. The seeds are usually black, green, or yellow; and range in diameter from one eighth to one quarter of an inch. The size of the plant, the habit of growth, and the size and color of the seeds vary even more than these characters of the cowpea. While most of the varieties are erect and vary in height from 1 to 4 feet, some sorts have small seeds, small leaves and a trailing habit, the vines reaching a length of several feet. The most prominent varieties are Mammoth, Ito San, Medium Yellow, Hollybrook, and Wilson.

498. Importance. The soy bean does not yet occupy a very prominent place in the United States, though its importance is increasing rapidly. In China and Japan it is one of the most important crops for the production of grain and oil. As the plant is less easily injured by frost than the cowpea, it can be grown farther north. It is most useful along the northern border of the section where cowpeas are grown, from Kansas, Kentucky, and Maryland northward. The soy bean grows very well on poor and sandy lands, and is sure to become as important for the building up of poor soils and for forage in this region as the cowpea now is farther south.

499. Growing the Crop. The methods of growing soy beans differ little from those in use in the cultivation of the cowpea crop. The plants are more often grown in rows and cultivated, as the crop is generally grown for the production of seed as well as forage. The preparation of the soil should be thorough. Little fertilization is necessary, for the plants grow well on poor land and are able to obtain their supply of nitrogen from the air. Soy beans grow better on sandy or loam soils than on heavy clay. Inoculation with the proper bacteria is necessary for the best success in new districts. The tubercles of the soy bean are large, and they store up considerable nitrogen in the soil when the plant is grown under proper conditions.

Figure 127.—Soy bean plant. Note the nodules on the roots.

When the crop is to be cultivated, the rows should be from 2½ to 3 feet apart. As the plants stand upright, they can be cultivated longer than cowpeas. Three or four cultivations are usually sufficient, though the number depends on the soil and the season. Seed should not be sown till after danger of frost is past. It may be sown up to July 1 in the Central states, and three or four weeks later farther south. The rate of planting varies from 1½ to 2 pecks in rows to 4 pecks when sown broadcast.

500. Harvesting. The methods of harvesting differ but little from those described for the cowpea. The plants should not be allowed to get too dry in the swath, or there will be considerable loss of seed and leaves. As the seed

shatters readily, it must be cut before all the pods mature, else much of it will be lost. Small plats may be pulled by hand and the seed beaten out with a flail. Larger fields may be threshed with the ordinary threshing machine or with the special bean thresher. The seed should not be stored in large quantities without plenty of ventilation, for it is likely to heat, thus lowering the germination.

501. Uses of the Plant. The uses of the soy bean are more numerous than those of the cowpea. As the plants grow erect, they are easily harvested for hay. They are sometimes sown with sorghum, cowpeas, or other crops for the production of mixed hay or silage. The feeding value of the hay is about the same as cowpea hay, though stock do not eat the stems and pods as readily. As pasture, they are hardly so good as cowpeas. The grain is very rich in oil and protein, but contains little starch. In combination with corn, they produce very economical gains when fed to cattle and hogs. As the seeds are hard and not easily crushed by stock, they are usually ground and fed as meal. In China and Japan, the seed of the soy bean is an important article of human food, and is also used in the manufacture of oil. Soy beans are now being used as baked beans, either alone or in combination with navy beans, and are coming into use as human food in the United States in many other ways. Before many years, they are likely to become a common article in our diet and their cultivation is certain to increase immensely, for the uses of this plant as oil, food and forage are very numerous.

THE PEANUT

502. The Peanut, *Arachis hypogea*, differs from the other members of this family which are commonly cultivated in that the seed pods are produced below the surface of the ground. The peanut is believed to be a native of tropical South America. It is one of the few leguminous plants

native to the New World which have found their way into cultivation. The plant produces many leafy stems, from 12 to 18 inches tall. The leaflets are three in number and about 1 inch long. The flowers, which are produced in the axils of the branches, are small and yellow. After the flower falls away, the stem on which it grew elongates and enters the soil, and the pod or nut then forms below the surface. For this reason, peanuts can be grown best on loose soils.

503. Importance. While we ordinarily think of peanuts only as we commonly see the roasted nuts for sale on the street corners, the seed is largely used in the manufacture of oil and other articles, and the vines make excellent forage for stock. The average value of the peanut crop of the United States in the five years from 1918 to 1922 was $52,000,000, slightly more than the combined value of the buckwheat and flaxseed crops. It is largely produced along the Atlantic coast, the sandy lands there being particularly adapted to it. The larger portion of the market crop is grown in Virginia, North Carolina, Georgia, Alabama, and Texas. The production of peanuts was highest in 1918, when 1,865,000 acres were grown, producing 1,240,000,000 pounds. More than 1,000,000 acres are now grown annually.

504. Cultivation. Peanuts grow best in a fairly fertile sandy loam soil which has been well prepared. They should be planted in rows 30 to 36 inches apart after the soil is thoroughly warm in the spring, generally after corn has been planted. The seed of the larger varieties is usually shelled before planting, but the Spanish peanuts are often planted without shelling. The one-row planter is commonly used. The common rate of seeding is 1 peck of shelled Spanish peanuts or 5 pecks in the shell, while 1½ pecks of shelled Virginia peanuts will plant an acre. After the plants are up, frequent shallow cultivation should be given to keep the soil loose till the pods begin to form. The ground should not be disturbed again till harvest.

505. Harvesting. When the greater part of the nuts is mature, the crop should be harvested; for, if left longer, the nuts which ripened first are likely to sprout. The plants are usually dug with a potato digger or are plowed out, though

Figure 128.—The Virginia peanut, the type usually grown for the nuts. The Spanish peanut, which produces numerous small nuts, is grown for forage

small areas on loose soil can be pulled by hand with little loss. After the vines are pulled, they are left to dry slightly and are then put in small stacks to cure. These stacks are usually built around a framework which admits air to all portions of the stack. The top should be covered to prevent injury from rain, as the market value of the nuts is reduced if they are discolored.

After the vines are cured, the nuts are picked off by hand or removed by machinery, and are then cleaned and sorted.

The marketable nuts are put into large sacks for the market, while the smaller nuts are fed to hogs or other stock. The vines from which the nuts have been picked are of considerable value as forage.

506. Uses of the Nuts. By far the greater part of the market crop of peanuts is used in the production of peanut oil, peanut butter, and other similar food products, salted peanuts, and various peanut candies, though the quantity of roasted nuts consumed each year is considerable. The nuts are also fed to stock, particularly to hogs. The Spanish variety is often planted in the South for hog pasture, the hogs being turned in when the pods are mature and allowed to root out the nuts. As both the vines and nuts are eaten, this is a very economical method of producing pork. The peanut vines, especially if the nuts have not been removed, are very valuable as forage, and considerable acreages are grown in the South every year for this purpose.

THE FIELD PEA

507. Origin and Description. The field pea, or Canadian field pea, *Pisum arvense*, is a native of the region north of the Mediterranean Sea, and the latter name has been given to it simply because the plant is of more importance in Canada than elsewhere in America. It differs little in appearance from the common garden pea, except that the vines are larger and more vigorous than those of most varieties of the garden pea, and the flowers are usually pale purple or violet instead of white. The vines reach a length of several feet and some varieties branch quite freely. The pods, which are long and straight, contain several white or blue peas.

508. Importance of the Crop. Field peas are mostly grown in the states on the Canadian border and in Colorado. One of the most important districts is the San Luis Valley in the latter state. In Ontario and other portions of Canada the field pea is much more generally grown than in the United

States. In the Northern states and in Canada, peas are usually grown in combination with oats or barley for hay, though they are also grown alone for the seed.

509. Methods of Growing. The usual method of growing peas is to sow from 1 to 2 bushels of seed to the acre with a bushel of barley or oats, the grain furnishing a support for the pea vines and making them easier to harvest. The growth of peas is also better and they are less troubled with such diseases as mildew when they have some support. The seed is drilled in on well-prepared land as early in the spring as the ground can be worked. As the seed is much larger than that of the grains, it can be sown more satisfactorily separately than in a mixture, and the grain can be added by going over the field a second time. The common practice, however, is to sow the two at one operation. The use of the grain drill is desirable in order to get the seed covered to the proper depth. After the seed is sown, no further treatment is required until harvest time.

Figure 129.—Branch of field pea with pods and flowers.

510. Making and Feeding the Hay. Field peas should be cut for hay when the pods are filling but before any of them are ripe. At this time the grain with which they are sown should also be in the proper stage for hay. The crop can be cut with the ordinary mower or with a mower with buncher attachment. Curing in the cock is preferable to long curing in the swath, for raking after the pods are dry is likely to result in the loss of much of the seed. The curing of the hay is not different from that of similar hay crops.

The hay can be fed to stock of all kinds. In the San Luis Valley in Colorado, it is very largely used in the feeding of sheep. Grain and pea hay is excellent for dairy cows and for young, growing stock. Its feeding value depends to some extent on the proportion of peas and of grain, but it is richer than grain hay alone. Pea vines are about equal in feeding value to clover hay.

511. Other Uses of Field Peas. Peas and oats or peas and barley make excellent pasture for cattle, sheep and hogs, particularly if the stock is not turned in until the plants are nearly mature. Hogs and sheep will make large gains and there will be little waste if the crop is allowed to mature before the stock is pastured on it. This combination crop is sometimes put into the silo, and silage of high feeding value is produced. As a soiling crop, peas and grain have no superior for early feeding in the northern part of the United States. As the plants make a large volume of organic matter rich in nitrogen, they are excellent soil improvers when turned under as green manure. The grain may be fed whole to sheep or hogs or may be ground into meal. For hogs, grinding is advisable.

THE FIELD BEAN

512. The white, or navy, varieties of the common garden bean, *Phaseolus vulgaris*, are grown under field conditions for the production of dried beans in some localities, more particularly in Michigan, New York, and California. It is estimated that the bean crop of 1922 was worth more than $44,000,000. The usual method is to plant in rows from 30 to 36 inches apart, after the ground is warm in the spring, and give good cultivation during the growing season. Beans should not be cultivated when the leaves are wet with rain or dew, for they are much more likely to become diseased if disturbed when damp. The rate of seeding depends on the size of the beans, ½ bushel to the acre being sufficient for

the navy or pea beans, while as much as a bushel of some of the larger kinds is required.

When the beans are ripe, they are harvested with the bean harvester, an implement which runs just beneath the surface and cuts the stems and roots, so that the plants may be gathered readily, free from earth and roots. If the vines are practically dead when harvested, they may be placed at once in well-built cocks, but if there are some green pods and leaves, they should be dried for a few hours before bunching. These cocks are usually built around a pole about 5 feet high, sharpened at both ends. One end is stuck firmly in the ground and a bunch of grass or weeds is fastened to the other after the cock is completed, to serve as protection from rains. As soon as the vines are dry, they should be removed carefully to the barn, where the beans may be flailed or threshed out. The modern bean thresher removes the beans much more quickly and cheaply than the flail. After the beans are threshed, they should be cleaned and graded, and the good beans placed in sacks for marketing. The cull beans may then be used as feed for stock, while the marketable beans are an important article of human diet.

SWEET CLOVER

513. Description. The white sweet clover, *Melilotus alba*, is a common roadside plant growing quite generally over the United States. It is a native of Europe, but is widely naturalized in America. It closely resembles alfalfa in habit of growth, but is biennial, and the flowers are small, numerous, and produced in long spikes.

514. Importance. Sweet clover is not generally cultivated, though in recent years it has been grown to a considerable extent as a forage crop and soil renovator. Its principal use is for the latter purpose. Stock usually eat it readily after they become accustomed to it; but, unless it is cut early for hay, the stems are coarse and woody. The feed-

ing value of sweet clover is nearly the same as that of alfalfa, but both the green plants and the cured hay are less palatable. The young plants are less bitter and woody than older ones, and thus close pasturing is advisable.

515. Culture. When it is desired to grow sweet clover on poor soil to improve it, the seed is sown in the spring at the rate of about 15 pounds to the acre, and harrowed in. In the South, it can be sown after an early crop is harvested. If the plants are plowed under the following spring before blossoming, there will be no difficulty in eradicating it, but if it is allowed to seed it is likely to give trouble. The seed is so like that of alfalfa, that it sometimes is used as an adulterant.

Figure 130.—Sweet clover.

The same soils on which sweet clover thrives are usually adapted to alfalfa, and as the same bacterium lives on the roots of both plants, land on which sweet clover grows ordinarily does not require inoculation to produce alfalfa. Sweet clover, however, will grow on soils and in climates where alfalfa will not succeed. If acid, the soil should be limed.

Failure to secure a good crop, when cultivated, may be the result of poor seed. The germinating power of the seed should always be tested. On account of its hard coat much of the seed fails to germinate the first season. This plant also requires a firm soil. Of course the soil should be tested for lime. Sweet clover may be sown broadcast on rough or stony land, that is practically untillable. It may also be grown along river bottoms.

This crop should be pastured or cut down sufficiently to insure an abundance of fresh shoots for grazing. When harvested it may be cut with a binder and shocked, or with a mower and stacked. Where more than one crop is ex-

pected the first should be cut when it is about 30 inches high and before the flower buds have formed. A stubble of 4 or 5 inches should be left.

The delicate part of curing is to prevent the leaves from shattering. One should follow the general directions given for other clovers and alfalfa.

Sweet clover as a silage crop has been satisfactory.

Figure 131.—White Sweet Clover plant six weeks old. Note the extensive root system already developed. (F. B. 797)

THE BUR CLOVERS

516. The bur clovers are closely related to alfalfa, belonging to the same genus, *Medicago*, but are annual instead of perennial. They are low-growing plants with yellow flowers and prickly pods. The common species are *Medicago maculata*, or spotted medic, and *Medicago denticulata*, or toothed medic. Both species grow in the South, though the spotted medic is more common. The toothed medic is grown in California.

517. Use as Winter Pasture. A common practice in the South is to sow bur clover on Bermuda grass pasture in the fall. About the time the Bermuda grass is killed by frost, the bur clover begins to grow; in mild seasons it grows throughout the winter. It furnishes good pasture during the late fall and early spring months and, if allowed to produce seed, will reseed itself. In this way, a permanent pasture is assured. As the bur clover adds nitrogen to the soil, the growth becomes heavier from year to year.

518. Use as Green Manure. Bur clover is also sown in cotton or other cultivated fields in the fall and plowed under the following spring as a green manure crop. About 15 pounds of clean seed or 40 to 60 pounds of seed in the bur is sown to the acre. If it is not plowed under the following spring till seed is produced, it will not be necessary to reseed it in the fall.

JAPAN CLOVER

519. Japan clover, or lespedeza, *Lespedeza striata,* is a native of Japan which is now commonly found on sandy soils from Virginia to Texas. It is not usually sown, but, like blue grass and white clover in the regions farther north, it comes in and fills up the waste places. While the plant ordinarily grows only a few inches high, on good soil it reaches a height of from 15 to 18 inches, and is a promising hay plant. Its chief value is as gatherer of nitrogen on poor soil, and as a pasture crop. It is an excellent addition to Bermuda pastures, for it grows well with Bermuda or other grasses. As it soon starts into growth again when grazed off, the quantity of feed it will produce during a season is surprising. In pastures it will usually reseed itself. On richer lands where it is thick and tall enough to be cut for hay, some provision should be made for reseeding. Uncut strips should be left across the field or the first crop should be cut early enough to allow the second growth to mature seed before frost.

It is not usually necessary to sow lespedeza seed in pastures. To introduce this plant or to sow it on cultivated land for hay or as a renovating crop, 15 to 25 pounds of seed should be sown in the early spring and harrowed in. Most of the seed is now produced in Louisiana and Mississippi.

THE VETCHES

520. Description. Though several species of vetch are grown in various parts of the country, the most common is

the winter, or hairy vetch, *Vicia villosa*. This is sown in the late summer or early fall as a cover crop in orchards or in combination with fall grain as a forage crop for hay or for soiling. The vetch plant produces a trailing vine several feet in length, with numerous pinnate leaves consisting of eight to fourteen small leaflets. The bluish-purple flowers are produced in racemes in the axils of the leaves. The pods are straight, about 1½ inches long, and contain several brown or black seeds.

Figure 132.—Hairy vetch.

521. Culture and Uses. When sown for hay or as a winter cover crop and soil improver, from 1 to 1½ bushels of vetch seed are required for an acre. Oats or beardless wheat are good grains to grow with vetch for hay, while as a cover crop or green manure there is nothing better than rye. The time to cut for hay depends more on the grain than on the vetch, for it continues to grow and produces seed over a considerable period. Vetch is sometimes sown in the fall on Johnson grass sod and cut the following summer for hay. By the time the Johnson grass is ready to cut the vetch will have reseeded itself sufficiently to produce another crop the following fall.

The greatest usefulness of winter vetch is in the South as a cover crop and soil improver on poor lands, though its best growth is on fertile soils. In the Central and Northern states it must be sown in late summer or early fall to prevent winterkilling. As cultivation of orchards generally stops about that time, this plant works in well as a cover crop to add nitrogen. For the best growth of the orchard, it should be plowed under early the following spring, for if left to produce seed it will take moisture and plant food from the trees

THE VELVET BEAN

522. The velvet bean, *Stizolobium deeringianum,* is a semitropical plant which thrives along the Gulf Coast and in Florida. There it is an important forage plant and soil renovator, as it makes a very heavy growth and produces numerous nitrogen-gathering tubercles. The vines often grow to a length of 30 feet or more. The flowers are in clusters, purple in color, and are followed by short pods which are covered with black fuzz, or down. Each pod contains several mottled white and brown seeds about the size of a common garden bean. The greatest value of the velvet bean is as a producer of vegetable matter rich in nitrogen. The long, tangled vines make it rather difficult to harvest for forage. It will produce good sized vines as far north as Virginia and Kentucky, but does not produce seed except in the Gulf states. In recent years, however, two early varieties, the Georgia and the Alabama, have been produced, which mature seed almost anywhere in the Gulf states. These are now extensively grown, the area in velvet beans in 1919 being 1,143,562 acres, mostly in Georgia and Alabama.

Figure 133.—Velvet bean leaves, flowers and green and mature pods.

LABORATORY AND FIELD EXERCISES

The pupils should become familiar with as many of the plants discussed in this chapter as possible. Most of them can be grown to at least a partial state of maturity almost anywhere in the United States,

and at least a few plants of each (with the possible exceptions of the velvet bean and bur clover in the North) may well be grown on the school farm. They can be utilized as illustrative material in the fresh state in the field or dried and used in the laboratory at any season of the year. For growing in the northern portion of the United States, early varieties of cowpeas like New Era and of soy beans like Ito San should be selected.

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289. Beans.
515. Vetches.
690. The Field Pea.
693. Bur Clover.
886. Harvesting Soy Bean Seed.
797. Sweet Clover: Growing the Crop.
820. Sweet Clover: Utilization.
836. Sweet Clover: Harvesting and Threshing the Seed Crop.
931. The Soy Bean in Systems of Farming in the Cotton Belt.
962. Velvet Beans.
973. Soy Beans: Culture and Uses.
1005. Sweet Clover on Corn-belt Farms.
1127. Peanut Growing for Profit.
1143. Lespedeza as a Forage Crop.
1148. Cowpeas: Culture and Varieties.
1153. Cowpeas: Utilization.
820. Sweet Clover: Utilization.
836. Sweet Clover: Harvesting and Threshing the Seed Crop.

CHAPTER XXI

ROOT CROPS

523. Introduction. For convenience, all those forage crops which are not included among the grasses and legumes are grouped under the class name of root crops, though not all are grown for their roots. Practically all these plants are biennials which during their first season's growth store up food in their roots or stems to supply nourishment to the fruiting stem the following season. Such plants as beets, mangels, turnips, rutabagas and carrots are grown for their fleshy roots, which are really a thickening of the base of the stem and the top of the taproot. The head of cabbage is a mass of leaves closely folded together, while kohl-rabi is an enlargement of the stem rather than of the root. Rape and kale are closely related to the cabbage, but do not produce heads. The area in "root forage" for the entire United States in 1919 was more than 88,000 acres, with a total production of 599,000 tons. This includes only mangels, turnips, rutabagas, and carrots. These root crops are produced most largely in New York, Michigan, Wisconsin, Minnesota, Washington, Oregon, and California.

THE BEET

524. Classes. The beet, *Beta vulgaris*, has been developed into four distinct types, in each of which there are many varieties. These are (1) the chard, grown for its thick leaf stalks, which are used as greens; (2) the garden beet, grown for its edible roots; (3) the sugar beet, grown for the production of sugar; and (4) the mangel or mangel-wurzel, for feeding to stock. We are here concerned only with the latter type. The sugar beet will be discussed in Chapter XXIII.

525. The Mangel and the Sugar Beet. The mangel differs from the sugar beet in many characters. The root of the sugar beet is fairly uniform in shape, being largest near the crown and tapering gradually to a long taproot, while that of the mangel is of various shapes in the many varieties. The flesh of the sugar beet is white, while that of the mangel is usually reddish or yellow. The skin of the sugar beet is also white; the mangel may be red, white, golden, purplish, or even black. The sugar beet grows almost entirely below the surface of the ground, while in many varieties of mangel half or more of the root is above the surface, making it much easier to harvest. Well-grown sugar beets weigh from 1 to 1½ pounds; mangels should weigh from 4 to 6 pounds. The sugar beet contains about 20 per cent of solids, of which about four fifths is sugar; the mangel contains only about 12 per cent of solids and not more than 6 per cent of sugar.

526. The Soil and Its Preparation. The best soil for beets is a rich loam or sandy loam. The roots do not develop well in clay soils and are more difficult to harvest, while very sandy soils do not retain sufficient moisture. Conditions are usually more favorable in the Northern states than elsewhere for the growth of mangels. Good preparation is essential to the profitable growth of the crop. The seeds are somewhat slow to germinate and the plants grow slowly at first, so that every precaution should be taken to keep down weeds. They can best be prevented by planning a rotation which contains crops which aid in the control of these pests. One which has been successfully used in some sections consists of (1) corn, (2) barley, and (3) mangels or some other root crop. The land is manured for the corn. This crop may be fed off by hogs, if desired, as it will then be practically returned to the land. The cultivation of the corn crop and the rapid growth and early maturity of the barley all aid in subduing weeds. After the barley is harvested, the land is

plowed and then harrowed at intervals during the fall to kill any weeds that appear. The easy preparation of a good seed bed free from weeds is thus insured for the beets which may be grown the following spring.

The usual preparation for beets, whether or not the rotation just given is followed, is to plow the land in the fall and disk it deeply and thoroughly in the spring. From four to six harrowings and diskings are usually required to put it in proper condition for seeding. The land should be fertile. If it has not been manured for a previous crop, the application of a good supply of well-rotted manure is beneficial. Fresh manure should not be used, as it is likely to contain many weed seeds.

Figure 134.—Mangels produce a heavy yield to the acre and supply a large quantity of succulent feed for dairy cows and other stock.

527. Seeding. The seed of the beet is produced in "balls," or "bolts," which contain from one to five seeds. For this reason, it is impossible to regulate the rate of seeding perfectly, and hand thinning must be practiced to obtain a

uniform stand. The seed may be sown with a one-row drill, though where roots are grown in any quantity the use of a drill which sows several rows at a time is desirable. Mangels are usually planted in rows ranging from 28 to 36 inches apart; the rate of seeding is from 6 to 8 pounds to the acre. The seed is covered about 1 inch deep, or deeper if necessary, to insure moisture for germination. Seeding should be done as soon as the ground is in good condition, which is about the first of May in the Northern states, though on heavy soils it may have to be delayed till about May 20.

528. Cultivation. As soon as the rows can be followed, the land should be cultivated. The best type of cultivator is a four-row one with knives that cut just below the surface of the soil. Cultivation should be repeated every eight or ten days till the tops meet between the rows. In order to obtain a perfect stand and prevent crowding, the plants must be thinned to the proper distance as soon as they are large enough, which is about the time the fourth or fifth leaf is produced. They should first be "bunched," cutting out all the plants in the rows with a hoe except small bunches 1 or 2 inches wide and 10 or 12 inches apart. After the plants have recovered somewhat from the "bunching," but while they are still small, they are thinned by hand, all but the largest plants in each bunch being removed. The single plants should then be about 12 inches apart in the row. The bunching and thinning is slow and expensive work, and root crops are, therefore, not very popular among American farmers. It is more necessary for sugar beets than for other root crops, as uniformity is more important in that crop, and the seed is sown thicker to insure a full stand. Large yields being essential to the profitable production of root crops of all kinds, much depends on the preparation of the soil, its freedom from weeds, and the care which is given.

529. Harvesting. Mangels should be harvested as soon as growth stops in the fall, which is when the outer leaves

begin to wither. They should not be exposed to severe freezes, though the first light frosts will not injure them. The roots should be removed from the ground without breaking or bruising them, for bruised roots soon decay. If necessary, they may be loosened by plowing a furrow close beside the row, or by a beet digger run under the row, but mangels can usually be pulled easily by hand. The tops are then twisted or cut off and the beets thrown into piles from which they are loaded into wagons and hauled to the root cellar or pit for storing. The tops may be thrown into windrows for curing, as they make excellent feed for cattle, sheep, and hogs. If they are not desired for feeding, they should be scattered over the field and plowed under for fertilizer.

530. Storing. Mangels and other roots should be stored as soon as harvested. For this purpose, a root cellar is desirable, though not absolutely necessary. Good ventilation, freedom from dampness, and a temperature just above the freezing point give the best conditions for storing. If a cellar is not available, the roots may be placed in a pit and covered with alternate layers of straw and earth, increasing the depth of covering as the weather becomes colder.

531. Uses. Mangels are used as a substitute for corn and corn silage in the North and in high altitudes where the weather is too cool for that crop to succeed. The dry matter in mangels is equal in feeding value to the dry matter in grain and is somewhat higher than that in silage. It is palatable and nutritious, and an unusually high proportion of it is digestible. Mangels are most commonly fed to dairy cattle, though they may be fed to sheep and hogs, if desired. As from 10 to 15 tons may readily be produced to the acre, the farmers in the Northern states can well afford to raise more mangels and other root crops.

CARROTS

532. Description. The carrot, *Daucus carota*, has finely-divided leaves, flowers and seeds in a dense umbel, and roots

of various shapes and colors. Most varieties taper from the crown to the taproot, though some are cylindrical for most of their length, while others are short and thick. The color of the flesh and skin may be white, yellow, orange, or red. Carrots are grown in only a limited way for stock feeding, mostly for horses. Their feeding value is about the same as that of mangels.

Figure 135.—Carrots for stock feeding.

533. Culture. Carrots grow best in a deep sandy loam. The seed bed should be well prepared and free from weeds, as germination and early growth are slow. The rows should be from 24 to 30 inches apart and the plants about 3 inches apart in the rows. From 4 to 6 pounds of seed is required to sow an acre. The methods of planting, thinning, cultivating and harvesting are not different from those already given for mangels. Carrots yield from 10 to 25 tons of roots and 3 or 4 tons of tops to the acre.

TURNIPS AND RUTABAGAS

534. Description. The turnip and the rutabaga are closely related plants of the genus *Brassica*, which also includes mustard, rape, and several of our garden vegetables. The rutabaga is *Brassica campestris;* the turnip, *Brassica rapa*. The roots of turnips and rutabagas vary from the flattened form of the common turnip to the long, cylindrical "cowhorn" type in shape, and from white to yellow, purple,

and red in color. The flesh is white or yellow; it is usually white in turnips and yellow in rutabagas. Turnips mature more quickly, while rutabagas have a higher feeding value and keep better.

535. Culture. Rutabagas and turnips grow best in a cool, moist climate and in a sandy loam soil. The preparation of the soil, seeding, cultivation, harvesting, and storing are not different from the treatment which has been recommended for mangels. From 2 to 3 pounds of turnip and 4 to 5 pounds of rutabaga seed is required to the acre. As turnips make their growth in from two to three months, they may be sown in the late summer and yet mature a crop before frost. They grow best in cool weather, and for fall and winter use should not be sown till the latter part of July. Rutabagas, on the other hand, require from four to six months to reach maturity, and must be sown in May or June.

536. Uses. Turnips and rutabagas are largely used in England for feeding to stock, and to some extent in Canada, but they are seldom grown for this purpose in the United States. They are equal in feeding value to mangels and other root crops, and the grain ration may be materially reduced when they are used. Rutabagas are especially good for feeding to pigs. As turnips do not keep well, they should be fed in the early fall; rutabagas may be kept through the winter without much difficulty. When all the root crops are grown, turnips are usually fed first, being either pastured off or fed as soon as they are harvested; rutabagas are then used till about January 1, after which mangels are substituted. Rutabagas may be fed throughout the winter.

CABBAGE AND KOHL-RABI

537. Culture and Uses. Cabbage and kohl-rabi are different forms of the same original plant, *Brassica oleracea.* In cabbage, the food material is stored in the leaves, which form a compact head, while in kohl-rabi it is stored in an

enlargement of the stem, which looks like a rutabaga above ground. Cabbage is commonly grown as a garden vegetable, but is used to some extent for feeding to stock, while kohl-rabi is not extensively grown in America for any purpose. Cabbage produces a large yield of succulent feed, which is best used by feeding direct from the field in the fall. Kohl-rabi is said to be more drought-resistant and to grow in warmer climates than the rutabaga. These two are about equal in feeding value. Kohl-rabi should be sown in the same manner as the rutabaga and the plants thinned to about the same distance apart. Cabbage may be sown in the garden early in the spring and transplanted to the field in June by hand or with a transplanting machine, or the seed may be sown in hills about 24 inches apart, dropping three or four seeds in the hill and later thinning to a single plant. The rows should be about 3 feet apart and the plants about 24 inches apart in the row. Cultivation is the same as for other crops discussed in this chapter.

RAPE AND KALE

538. Description. Rape, *Brassica napus*, is a quick-growing, leafy plant with stems from 2 to 4 feet tall. The leaves grow along the stem instead of from the crown as in many of the other plants of this genus. The variety which is commonly grown in this country is the Dwarf Essex, a biennial type which produces seed only where the plants will survive the winter. Where it does produce seed, however, the yield is heavy, so that the seed is cheap, and as only 3 to 5 pounds is required to the acre, the expense of seeding is small. Kale, or headless cabbage, one of the numerous forms of *Brassica oleracea*, grows in much the same form as rape, but has larger leaves and produces heavier yields of forage. It is grown as a forage crop only in the mild climate of western Oregon and western Washington.

539. Culture. Rape grows best on rich, moist loam soils. Its growth is rapid, hence it is often sown broadcast, as it is

able to compete successfully with weeds. Larger yields are obtained, however, if it is sown in drills from 28 to 36 inches apart and given frequent cultivation while the plants are small. As the plant is a gross feeder, it can use large quantities of stable manure or other fertilizers. The yields from poor soil are likely to be disappointing, but the quantity of forage produced on rich soil is remarkable. Rape may be sown alone at any time during the spring or early summer months, or with oats or other grain in the spring. When sown with grain, not more than 1 or 2 pounds of rape seed to the acre should be used. The rape usually grows slowly till the grain crop is removed, when it starts into rapid growth and supplies abundant forage. In wet seasons on rich soil, it sometimes makes such rapid growth that much of it is harvested in the butts of the grain bundles, thus interfering with their proper curing. Sowing the rape a couple of weeks later than the grain usually avoids this trouble, while the rape succeeds quite as well. As it survives frost well, it may be counted on for later pasture.

540. Uses. It is customary to pasture rape, when it is sown either alone or with a grain crop. Occasionally, it is cut for soiling, but it is never cured into dry fodder. It is most largely used as pasture for hogs and sheep. Better results are obtained if stock are pastured on only a part of the field at a time, using movable fences or hurdles and changing the animals to different areas as necessary. Otherwise, much of the feed is wasted by the animals' tramping it into the soil. Rape is a succulent, palatable feed, very similar in composition to the best perennial pasture crops, and as it produces a large quantity of forage in a short time, it should be more extensively used. Care should be taken to prevent bloating when cattle or sheep are first turned on it. When sown with grain crops and pastured after the grain is harvested, sheep will put on flesh rapidly, as they get the benefit of the gleanings as well as the rape.

Kale is used quite extensively as a fall and winter soiling crop for dairy cows and other stock in Oregon and Washington west of the Cascade Range. As the winters are mild, it may be cut at any time from October to April.

LABORATORY AND FIELD EXERCISES

1. Collect seeds of garden beets, sugar beets and mangels. Describe the differences definitely. Sprout some of these seeds also and compare character and number of sprouts. What bearing would the result of this observation have on planting?

2. Compare the flesh, color, size, and shape of these roots. Distinguish the tops carefully so as to be able to recognize them readily.

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PART IV—MISCELLANEOUS CROPS

CHAPTER XXII

TUBER AND ROOT FOOD CROPS

541. Introduction. The principal tuber and root food crops of the United States are the common Irish, or white, potato and the sweet potato. The Irish potato, which is used as food and in the manufacture of starch and alcohol, is a tuber, or a thickened underground stem. Several of these are produced on each plant a little below the surface of the ground. They develop from offshoots of the main stem. On the other hand, the portion of the sweet potato which is used as food is a thickened true root. The white potato is most largely grown in the North, while the culture of the sweet potato is confined almost entirely to the South.

THE POTATO

HISTORY AND CLASSIFICATION

542. Origin and History. The common white, or Irish, potato, *Solanum tuberosum*, is a native of the mountain valleys of Peru and Chili. Some investigators believe that it has been grown in these countries for two thousand years, but this is merely a supposition. De la Vega found the Peruvians cultivating potatoes in 1542, and sent some of the tubers to Europe. Several later importations were made into Spain, and from these the growth of potatoes has spread until now practically all the countries of the world grow this crop to a greater or less extent. The potato was introduced into Ireland in 1586, and soon became an important article of food, as indicated by the common name "Irish" potato. It

was probably introduced into the United States during the colonization period by early Spanish settlers.

543. Botanical Characters. The potato is a fibrous-rooted plant which is perennial by means of the tubers it produces. It is for these tubers that it is grown, and by means of them it is propagated. As the tubers will not stand freezing, they are stored over winter, and thus the potato is grown as an annual. The plants grow from 2 to 4 or 5 feet long; the stems are smooth and somewhat angular. When the plant reaches its maximum length it is usually recumbent, with the leaves and branches stretching up from 1 to 3 feet. The compound leaves vary with the different varieties and stages of growth. The leaflets are generally ovate.

The white or purple flowers appear in terminal clusters. They are about 1 inch in diameter, with a five-parted, bell-shaped corolla. Each flower has five stamens and a two-celled pistil which occasionally matures seed. When seed is matured, it is often unlike the parent plant, because the flowers are cross-fertilized. Most of the new varieties of potatoes are obtained by planting this seed and making selections from a large number of seedlings, most of which are practically useless. Potatoes are most universally reproduced from tubers, and when one ordinarily speaks of seed potatoes he has reference to the tubers and not to the true seed. Numerous slight indentations, or "eyes," are to be found on the surface of the tubers. These are most numerous at the "seed" end, while there are comparatively few at the "stem" end where the tuber was attached to the parent plant. It is from the buds in these eyes that new plants are produced when the tubers or portions of them are planted.

There are about nine hundred species of the genus *Solanum*, but only a few are cultivated plants. The tomato and nightshade belong to this genus, and tobacco belongs to the same family. Potatoes and tomatoes are so closely related that the branches of one may be grafted upon the other.

544. Varieties. There is a very large number of different varieties of potatoes. Some are distinct types, but many of them are simply new names given by seedsmen to old standard varieties, for the purpose of encouraging their sale. While the varietal characteristics are quite pronounced, it is not always possible to distinguish even between well-known kinds, because a variety will vary greatly if grown under different soil conditions, and especially if grown and selected by different individuals. Some of the desirable characteristics in potatoes are good yield and quality, medium size, smoothness, and shallow eyes.

There are many different ways of classifying potatoes. They may be divided into early and late, white and red, smooth and rough, deep and shallow-eyed, or as long, flat, or round, etc. The most common classification, however, is early and late. Some of the well-known early varieties of potatoes are Early Ohio, Bliss Triumph, and Early Rose. These potatoes will usually produce a crop in from 70 to 100 days from planting. Some of the more common and generally distributed late varieties are Rural New Yorker, Sir Walter Raleigh, Carman No. 3, and Burbank. These varieties, as a rule, yield more than the early varieties. They require from 100 to 130 days in which to mature a crop.

IMPORTANCE OF THE CROP

545. World Production. During the five years, 1909-1913, the average annual production of potatoes in the world was about 5,480,000,000 bushels. These figures place potatoes in the lead of all other crops in the total number of bushels produced. The average production of wheat, corn, and oats for the same years was approximately 4,000,000,000 bushels each. Germany leads the world in total production of potatoes as well as in the average yield per acre. The six leading countries and their average annual production for the five years from 1909 to 1913 are as follows: Germany,

1,682,000,000 bushels; European Russia, 1,252,000,000 bushels; Austria-Hungary, 702,000,000 bushels; France, 485,000,000 bushels; United States, 357,000,000 bushels; and Great Britain and Ireland, 254,000,000 bushels. The immense total world production indicates the very general and extensive use of this crop. The average acre yields obtained in some of the leading potato-producing countries during the ten years from 1904 to 1913, inclusive, are as follows: Great Britain and Ireland, 210 bushels; Germany, 201 bushels; France, 130 bushels; Austria, 115 bushels; Russia, 106 bushels; and United States, 96 bushels.

546. Production in the United States. As shown by the preceding paragraph, the United States produces only about 6.5 per cent of the world's crop of potatoes. In the five years from 1918 to 1922, inclusive, an average of 3,953,000 acres was devoted to the potato crop of the United States, from which 390,173,000 bushels were produced, worth $425,826,000. The average annual acreage, production, and value of the potato crop in the leading states is shown in Table XIX

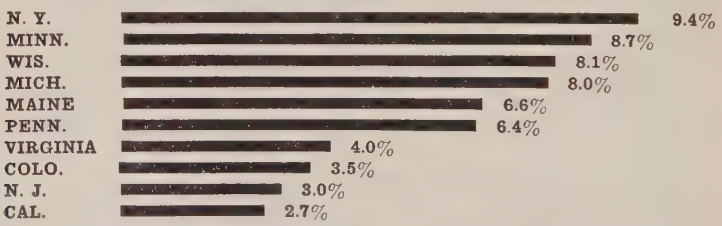

Figure 136.—Percentage of the potato crop of the United States which was produced in each of the ten states of largest production in the five years from 1918 to 1922, inclusive.

Ten states produce nearly three fifths of the potato crop of the United States, as shown in the accompanying diagram (Figure 136). The remainder of the crop is distributed over practically the entire area of the country, potatoes being produced to some extent in every state in the Union. The states of largest production, however, are mostly along the northern border. This crop is of greater importance

in Maine than in any other state, occupying more than 5 per cent of the improved farm land.

547. Acre Yield. The yield per acre obtained in the different states varies greatly. With the exception of Maine, the states which produce high yields grow only comparatively small acreages of potatoes. The average yield per acre is higher in Maine than in any other state. In the Rocky Mountain and Pacific states the yield is usually high,

Table XIX. Average acreage, acre yield, production, and farm value of potatoes in the ten leading states and in the United States during the five years from 1918 to 1922, inclusive.

State	Area	Acre yield	Production	Farm value December 1
	Acres	*Bushels*	*Bushels*	*Dollars*
New York	337,000	109	36,609,000	40,303,000
Minnesota	376,000	91	33,843,000	27,672,000
Wisconsin	311,000	101	31,437,000	25,775,000
Michigan	336,000	93	31,365,000	26,780,000
Maine	122,000	213	25,949,000	26,446,000
Pennsylvania	254,000	98	24,758,000	32,886,000
Virginia	143,000	109	15,528,000	16,584,000
Colorado	101,000	133	13,512,000	11,209,000
New Jersey	96,000	122	11,646,000	14,793,000
California	75,000	138	10,374,000	13,134,000
All others	1,802,000	86	155,152,000	190,244,000
United States	3,953,000	99	390,173,000	425,826,000

as the crop is grown under irrigation. Except California, Colorado, and Idaho, none of these states produces potatoes in quantity. In most of the important potato states, the yield is around 100 bushels to the acre.

SOILS AND FERTILIZERS

548. Soils. Potatoes, like many of the other farm crops, are grown on almost all classes of soil. Medium light loams are best adapted to potato growing, and are likely to give the best quality of tubers, though some excellent potatoes are produced on very heavy clay. The greater portion of the crop is produced on the lighter types of soils. Sandy and

sandy loam soils are especially desirable for producing smooth, clean potatoes of high quality. Such soils, however, are quickly exhausted, unless kept up by the rotation of crops and by the application of manure. Any soil, to produce a good crop of potatoes, should be well supplied with vegetable matter, and be rich and mellow to a considerable depth.

549. Manures and Fertilizers. Stable manure is one of the most desirable fertilizers for potatoes. It not only furnishes the necessary plant food, but helps to loosen the soil and to hold moisture, providing conditions very favorable for potatoes. On ordinary soils, a dressing of from 8 to 15 loads of stable manure to the acre, well-mixed with the soil, is a suitable application for the crop. Potatoes use much potash, but most soils are well supplied with this element. When commercial fertilizers are used, a complete fertilizer containing from 2 to 4 per cent of nitrogen, 6 per cent of phosphoric acid, and 8 per cent of potash, is usually applied. Five hundred pounds or more of this fertilizer is applied to the acre, the rate depending upon the condition of the soil. In the South, where soils are subject to considerable washing and loss of fertility during all or nearly all the year, larger applications are usually made, often from 1,000 to 2,000 pounds to the acre. On some of the lighter types of soils, or where leaching is at all likely to take place, the fertilizers are often added during the growing season. When fertilizers are high in price, smaller applications are made particularly of potash.

GROWING THE CROP

550. Preparing the Land. Soil for potatoes should, as a rule, be plowed deep, from 8 to 10 or 12 inches on the better soils. It is not desirable, however, to plow an extremely light soil so deep, unless it has been heavily fertilized with stable manure, and the manure thoroughly mixed with the soil.

Fall plowing is to be preferred, though equally good results can usually be obtained if spring-plowed land is thoroughly prepared. If the land is plowed in the fall, it becomes disintegrated and packed by settling and from the action of the weather, and, when the upper surface is cultivated and put in good condition in the spring, a better seed bed is obtained than is commonly the case with spring plowing.

If land is plowed in the fall, it is important that it be harrowed early in the spring to aid in warming up the soil and to conserve moisture. Fall-plowed land which is left hard and compact for several weeks after it thaws in the spring will probably be in poorer condition than well-cared-for spring-plowed land. The potato crop is capable of bringing comparatively large returns to the acre, and it is usually better to expend more labor and fertilizer in getting the soil in first-class condition than is practical with grain and corn crops, which do not give as large returns.

In some places where potatoes are grown in an intensive way and where large yields are very important, the land is plowed in the fall and again in the spring. The fall plowing, which is comparatively shallow, aids in saving moisture, destroys many weeds and insects, and leaves the land open to the action of the elements during the winter. If manure is to be used, it is applied during the winter or in early spring, on top of the fall plowing, and thoroughly disked into the upper 3 to 5 inches of the soil. The land is then plowed in the spring 2 or 3 inches deeper than it was in the fall, and the plowing followed by thorough disking and harrowing. While this practice is not at all general, it is advisable in very many instances.

551. Seed. Much profit is lost, under the common methods of growing potatoes, from the planting of poor seed. There is some tendency for potatoes to "run out" if grown on any but the very best soil, unless care is used in their selection. The first indication of the "running out" of a

stock of potatoes is seen in the tubers' becoming somewhat pinched or constricted at the seed end, and longer in proportion to the thickness than is typical of the variety. One must have clearly in mind the desirable type of the variety, and select persistently to that type. If this policy is followed, potatoes may be grown successfully for years without deterioration or without having to introduce new seed. Some of the desirable types of potatoes are shown in Figure 137.

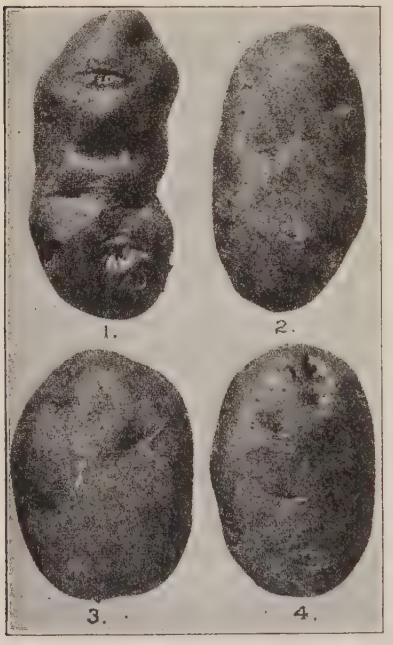

Figure 137.—Types of potatoes. No. 1 is an undesirable type, irregular in shape and with deep eyes. The others are smooth and regular and have shallow eyes. No. 2 is Burbank; No. 3 is Carman; No. 4 is Early Ohio.

The only condition which seems to require a change of seed is found in the South. The condition is not brought about by deterioration in the stock but by the difficulty experienced in keeping the seed till planting time, owing to the warm climate. Much of the seed used in the South is shipped in, and in Maine, Michigan, Minnesota, and some of the other Northern states a good business has been developed in providing seed stock for the South. This seed is usually stored in the North and shipped south only in time for planting.

A point that must be considered in selecting seed potatoes, especially if one is raising them for market, is the market demand. Too many growers have individual preferences

regarding varieties and types of potatoes and try to raise potatoes that please them, without regard to the kind that the large buyers want; consequently they experience difficulty in selling their crop at good prices. Buyers, as a rule, want medium-sized, smooth, clean, shallow-eyed potatoes of good quality. If one takes into consideration the fact that it costs from 5 to 10 cents more to peel a bushel of rough, uneven potatoes than of smooth, uniform ones, and that the loss in peeling the deep-eyed kind is very much greater, a very good reason will be seen why the dealers are willing to pay from 15 to 25 cents more for potatoes of a good type. By growing only such potatoes as the market demands can one hope to secure the best prices for one's surplus.

552. Preparing Seed for Planting. Potatoes always show a tendency to sprout as soon as the weather becomes warm. The production of sprouts that are long enough to break off in handling takes just so much plant food from the seed tubers. Seed potatoes should be kept in a cool place during the spring, and stored so that air can circulate freely about them. A low temperature can usually be maintained in the root cellar or basement if the windows and doors are opened during the night and closed during the hotter part of the day. It is usually well to treat potatoes for scab before planting (Section 568).

553. Cutting Seed. Experiments have shown that pieces of seed potatoes weighing 2 or 3 ounces give better yields than smaller pieces. The general practice, however, is to plant about 10 bushels of seed to the acre. To plant an acre with that quantity of seed, the pieces must be cut to about an ounce in size, if planted at the usual distances. One eye is sufficient for each piece. If one-ounce pieces are used there will usually be more than one eye on each piece, but as a rule only one will grow to any extent, and so the additional eyes are not objectionable. When potatoes are grown on a large scale, they are cut with a machine with stationary

knives so arranged that a potato laid on top of the knives and pushed down over them will cut in pieces of about the right size. Occasionally pieces without eyes may be cut by this method, but so seldom that machine cutting is entirely satisfactory. When potatoes are grown on a small scale, they are usually cut by hand with a knife.

554. Planting. The most common method of planting potatoes is in drills from 3 feet to 3½ feet apart, with one seed piece dropped at intervals of from 14 to 20 inches. Planting in this way requires about 10 to 12 bushels of potatoes to the acre.

The time of planting naturally varies with the location. In the Northern states, potatoes for early market are planted as soon as the ground can be put in good condition in the spring. The later crop is planted at any time in May, and sometimes as late as June 15. Farther south, the planting may be done at any time from January to the first of April. Where two crops a year are grown, one is usually planted in January or February, and the second in July or August.

The depth of planting will vary with the soil and kind of cultivation to be given. On the lighter soils, potatoes are commonly planted from 4 to 5 inches deep and given level cultivation. On heavier soils, especially where the land is a little too wet, they are planted more shallow and are hilled.

Where potatoes are grown on a small scale, as for home consumption, they are usually planted by opening furrows with a common plow or with a winged shovel. The seed pieces are dropped in these furrows by hand, and covered with the harrow or the sulky cultivator. Where a large acreage is to be grown, a potato planter is commonly used. Some of these machines are supplied with pickers that pick up the seed pieces and drop them at regular intervals. This type may be operated by one man. Another type is known as the two-man potato planter; this requires a driver and an additional man or boy to help in feeding to regulate the

drop. This latter type is regarded as more accurate, but is slightly more expensive to operate. These potato planters are equipped with a shovel which opens the furrow into which the seed pieces are dropped, and with disks which run behind and throw the earth on the row to cover them. A marker is provided to mark the next row as one is being planted.

Figure 138.—The potato planter. A good machine to use where several acres of this crop are to be planted.

555. Cultivation. The cultivation of potatoes is not very different from the cultivation of corn, except that potatoes planted in the ordinary way, from 3 to 5 inches deep, may be harrowed before the plants are large enough to cultivate, without danger of injury, as is not so true of corn. As soon as the rows can be seen, potatoes are commonly cultivated with the ordinary corn cultivator. The deepest cultivating should be done the first time through; for no injury is done if young plants are covered in the operation. In fact, covering is often practiced to protect early potatoes from a prospective frost. The subsequent cultivation should be sufficient to keep the surface soil in good mellow condition

and destroy all weeds without injuring the roots of the potatoes. On deep, rich, well-drained land, the potato roots are likely to grow so deep that thoroughly good cultivation may safely be given to a depth of from 2 to 3 inches. Cultivation may be continued until prevented by the spread of the vines. The later cultivations are usually given with a one-horse, fine-toothed cultivator.

556. Irrigation. As the potato crop gives large returns to the acre, it is quite commonly grown on irrigated land. The method of planting in drills also greatly facilitates the process of getting water to the crop. Extremely large yields of potatoes are obtained under irrigation; in fact, with the exception of Maine, the states producing the largest average yields per acre are those in which the main part of the crop is irrigated.

HARVESTING AND STORING

557. Harvesting. As a rule, potatoes are not harvested until they are ripe; that is, until the vines are entirely dead. High prices, however, may make it profitable to dig early potatoes before they are fully mature, even though a smaller yield is obtained. Where only a small acreage is grown, the crop is commonly dug with a fork, the potatoes from two rows being thrown together. Potatoes may also be plowed out with a common plow. The potatoes that are thus exposed are picked up; then the land is harrowed and others are brought to the surface. This method, however, is not in general use, because all the potatoes are not obtained. Where large acreages are grown, a four-horse potato digger is commonly used. This machine is equipped with a broad, sharp point which runs under the row and carries the earth, vines, and potatoes over a chain elevator through which the earth falls, leaving the potatoes to be dropped behind. There are several different types of potato diggers, but all work on approximately the same principle. Digging by machinery is by far the most satisfactory where there is much digging to do.

558. Picking. No satisfactory method of picking up potatoes by machinery has as yet been invented. Picking is done by hand, the picker using a basket, a bushel box, or a sack. Sometimes several baskets are set on a stone boat and hauled between the rows with one horse, the pickers tossing the potatoes into the baskets. In Maine they are commonly gathered in baskets and then put into barrels for marketing.

Figure 139.—A good potato digger.

559. Sorting. Some small potatoes are always produced with the large ones, and often there are irregular, sunburned, and diseased tubers. If these are mixed with the good, smooth, uniform potatoes the quality of the whole crop is lowered. On this account most growers find it profitable to sort their potatoes, offering for sale only the best grade, and using the poorer ones for stock feed or for the manufacture of flour, starch or alcohol. Sorting is best done when the potatoes are being gathered, for at that time one can most easily reject the undesirable tubers. Machines for sorting are used to a considerable extent, but these of course can be effective only in separating potatoes according to size.

560. Storing. Potatoes keep best at a temperature between 32° and 40° F., though necessarily they are often kept for a considerable length of time at higher temperatures. Early in the fall they are very commonly put in piles on the

ground in the field where they grew, the piles being covered with potato tops, straw, or hay, and a little earth. They may be kept in these piles until late in the fall, or even all winter, if necessary. If they are to be left throughout the winter, a pit is usually dug several feet deep and filled with potatoes and covered as stated above. As the weather gets colder, more earth or manure is piled on top to prevent freezing. It is always desirable in a pit of any kind to leave a small opening for ventilation.

Potatoes are also often stored in cellars under houses, a practice not usually advisable, except for small quantities for home use, if unavoidable, because the cellar is likely to be too warm and if any of the potatoes spoil they make conditions in the house very unhealthful for its occupants. Root cellars built separate from the house and potato warehouses are far better storage places. Root cellars are usually built underground and covered with a considerable depth of earth. Such cellars are usually cool in warm weather and sufficiently warm to protect potatoes from freezing in cold weather. If dry and well ventilated, they serve their purpose very well. Potato warehouses are usually built near railroad tracks so that shipments may be made from them at any time during the winter. The walls of these houses are usually made as nearly frost-proof as practical, and, if there is danger of freezing, stoves are used to raise the temperature slightly.

MARKETING AND RETURNS

561. Marketing. Potatoes are usually marketed as table stock, as seed stock, or as white or red stock, the prices for each kind depending upon the demand. By far the greater portion of the potato crop is marketed as table stock, and better prices are secured if carload lots of one type and variety can be sold. In many localities, small growers are seriously handicapped by the fact that it is practically impossible for their buyer to get a carload of uniform stock, hence all the

potatoes in the community, though they may be good in quality, must be sold as mixed stock, bringing a comparatively low price. Small growers are overcoming this difficulty by agreeing to grow but one or two standard varieties.

The time of marketing is always a matter of judgment. Sometimes one can get better prices by holding potatoes for several months before selling, and again the price may be lower after that time. Those who grow seed potatoes for the southern market must provide some way of storing them, because the southern buyers do not want them until near planting time. Many communities in the North have organized companies and have erected co-operative potato warehouses, that they may store their crop, if necessary, and ship when prices are best.

562. Cost of Production. The cost of growing potatoes normally varies all the way from $30 to $80 per acre, depending upon the system of cultivation, price of labor, rent of land, number of sprayings given, and cost of fertilizer applied. The Minnesota station found that in the potato-growing sections of that state, the average cost of growing potatoes in the Red River Valley in 1919 was $78.00 to the acre, and near Minneapolis it was $88.00. In Aroostook County, Maine, in the same year the average cost was $219.60 to the acre. The various items that must necessarily be considered in determining the cost of producing potatoes are plowing, harrowing, seed, cutting and treating seed, planting, fertilizers, cultivation, weeding, spraying, digging, picking, hauling, storing, sorting, machinery cost, and land rental.

563. Prices. There is a greater variation in the prices obtained for potatoes than for most of the other general farm crops, due to the fact that the surplus of one season cannot be carried over to the next. There is also a great variation in price during the same year in different sections of the United States, owing to the bulkiness of the crop and the

cost of handling and transporting from one place to another. The average farm price of potatoes in the United States in the five years from 1918 to 1922, inclusive, was $1.12 per bushel. The average price in Texas in the same five years was $1.96; in South Carolina, $1.63; in New York, $1.11; and in Minnesota, 87 cents.

In this connection it may be noted that the states where the high prices prevail are those which grow very small acreages and produce comparatively low yields, and that all these states ship in potatoes rather than have a surplus to ship out. A large part of the crop of the Southern states is early potatoes shipped to the northern markets in early spring, when they often bring a high price. During the fifty years, 1866-1915, the highest average farm price of potatoes in the United States on December 1 was 79.9 cents, in 1911; the lowest was 26.6 cents, in 1895. In 1919, a year of general high prices and of a short potato crop, the average farm price was $1.59. The average acre value of potatoes in the United States in the five years, 1918-1922, inclusive, was $109.56. The highest acre values of the potato crop are found in Maine and in the West. The average farm value in Maine in the five years mentioned was $221.71, and in Nevada, $182.29. The lowest value per acre was in North Dakota, $69.12.

564. Exports and Imports. As potatoes are bulky and perishable, they are not ordinarily shipped long distances, and do not enter largely into export and import trade. On the average the movement of potatoes into the United States equals the movement out, the average exports and imports in the five years from 1916 to 1920 each being 3,631,000 bushels.

ROTATION

565. Rotations for Potatoes. Potatoes fit into a rotation very much as corn does; that is, it is a good crop to follow clover or grass and grain crops succeed well following it.

Grain crops are slightly more likely to lodge following a potato crop, probably due to the fact that potatoes draw rather heavily on the potash supply and leave the soil more mellow and loose than corn.

A very common rotation in the general potato-growing sections in the North is: First year, clover; second year, potatoes; and third year, grain. In this rotation the potatoes are planted on clover sod, and if available, a good application of manure or commercial fertilizer is added. On light or worn soils, such a rotation is desirable, at least until the condition of the soil is greatly improved. In many cases, soils thus cropped have become so enriched as to cause succeeding grain crops to lodge. The rotation may then well be changed to a 4-year system, introducing a crop of corn following the potato crop. Such a rotation would then be: First year, grain; second year, clover; third year, potatoes; fourth year, corn. The two cultivated crops, corn and potatoes, usually draw heavily enough on the fertility so that the succeeding grain crop will not grow too rank and lodge.

In the South, the supply of vegetable matter is maintained usually by growing cowpeas or some other green manure crop, preceding and following the potato crop. A 2-year rotation commonly followed is: First year, corn and cowpeas followed by rye; second year, Irish potatoes followed by winter vetch or crimson clover.

DISEASES AND INSECT ENEMIES

566. Blight. The more prevalent diseases are blight, scab, and internal brown rot. Blight appears in two forms, the early and the late. Early blight attacks the leaves of the potato plants early in the season, and gradually spreads until the entire plant is killed. It is usually first seen as dark spots on the leaves. Late blight attacks the plants in a somewhat similar manner, but considerably later in the season. It first affects the plants near the ground and

spreads rapidly upward; the diseased parts quickly turn black and wilt. The spores which fall from the leaves to the ground may infect the tubers and cause them to rot, thus completely destroying the crop.

Blight is controlled by spraying the potato vines thoroughly with Bordeaux mixture several times during their

Figure 140.—Spraying to prevent disease and insect injury is an important part of modern potato growing.

growth. Bordeaux mixture is made by dissolving 5 pounds of high-grade stone lime in 25 gallons of water and 5 pounds of blue vitriol (copper sulphate) in 25 gallons of water in another receptacle. When the blue vitriol is completely dissolved, the contents of the two barrels are poured together and the mixture is complete. Care must be taken that sufficient lime is used, or the mixture may injure the plants. The treatment has no effect after the disease has started, but is a preventive which must be used often enough to pre-

vent the germination of the blight spores. The common practice is to spray the crop first when the vines are from 6 to 8 inches high, and repeat the spraying every ten days or two weeks, or often enough to keep the vines well coated with the mixture. There are some sections where blight is not sufficiently troublesome to warrant spraying, but in most instances it proves profitable.

567. Internal Brown Rot. In some sections and in some seasons, internal brown rot causes immense losses, while in other sections the disease is hardly known. The disease usually gets into the soil with the seed potatoes, or it may live over in a soil that has produced diseased potatoes. It may be seen when tubers are cut open as a dark brown streak around the potato a short distance from the surface.

The only remedy for this disease as yet known is to make sure that clean seed is planted. Care must be used in cutting seed to let nothing get into the field that shows any indications of the disease. A rotation of crops which provides for the growing of potatoes but once in several seasons on the same soil is also effective.

568. Scab. Scab, which attacks the outside of the tubers, causing rough, unsightly blotches, also does immense damage throughout the country. The disease may be carried over in the soil or on the seed. As it works on the outside of the tubers, it may be controlled by treating the seed. Potatoes that show any indications of scab should be treated before they are cut. Mix 1 pound of 40 per cent formaldehyde in 30 or 35 gallons of water and soak the seed potatoes in this solution for two hours. If the soil is infected with scab, potatoes should not be planted on it for several years. Plowing under green manure crops which will develop acid in the soil is somewhat effective in destroying the spores.

569. Insects Injurious to Potatoes. There are numerous insects which affect the potato crop. Cutworms, wireworms, and grubs often attack the crop on sod land.

The control of these pests has been discussed under corn. By far the most troublesome insect is the potato bug, or Colorado beetle. The mature beetle lays its eggs on the under side of the leaves of the potato. The larvae feed on the leaves and if not checked will strip the plant, thus preventing further growth. These beetles cause an immense loss to the potato crop throughout the United States every year.

Potato beetles are usually controlled by spraying the vines with Paris green, arsenate of lead, or arsenite of soda. By far the most common poison is Paris green. This is mixed in water at the rate of from 1 to 4 pounds in 50 gallons, and sprayed on the vines either by hand with a whisk broom, with a small knapsack sprayer, or by a large horse sprayer that will spray several rows at a time. The machine employed usually depends on the extent to which the crop is grown. It is important that the solution be applied quite thoroughly to all parts of the plant, and in sufficient strength to be sure to destroy the beetles. The use of a poor grade of poison or of a weak solution may make the work ineffective. Early and effective spraying is imperative. Spraying for both blight and beetles may be accomplished by mixing poison with the Bordeaux mixture, instead of with water, and applying both at one operation.

IMPROVEMENT OF THE CROP

570. Crossing. Improvement in potatoes is commonly accomplished in two ways, by selecting new varieties grown from seed and by selecting the best tubers from the best hills of some of the common varieties. If seed produced on potato vines is planted, there will be great variation in the plants which are obtained. This variation gives the breeder a wide range from which to select. Crosses between two varieties of known characters are sometimes made artificially with a view to combining in one variety the good qualities of both. The desired results are not always secured, as the poor quali-

ties of two varieties crossed are as likely to predominate in the progeny as the good ones. Good results, however, are sometimes obtained from intelligent crossing and subsequent selection, some of our leading varieties of potatoes having been produced in this way.

571. Selection. Breeding by selection is by far the most common method of improving varieties of potatoes, and one which may be practiced with profit by any careful grower. It is based on the fact that the productivity of individual tubers in a variety differs. By selecting those tubers which appear to be best and then comparing their productivity by planting them in a uniform field and harvesting the product from each tuber separately, those which produce large yields of good quality may be preserved and propagated.

The method of selection most practical on the average farm is to observe a large number of hills as they are dug and save for seed the tubers from hills that produced the largest number of desirable potatoes. Many experiments have shown marked improvement from such methods of selection.

Large potatoes are preferable as seed.

THE SWEET POTATO

572. Origin and Description. The sweet potato is a native of the New World and quite probably also of eastern Asia, as it was cultivated in China in early times. It was not known in Europe till after the discovery of America. The edible portion is a true root, one of the few roots used as food. The plant is a member of the *Convulvulaceae*, or morning-glory family; the species is *Ipomea batatas*. The plant produces numerous running vines several feet in length, with smooth, shining leaves about the shape and size of those of a morning-glory. The edible roots are produced in a cluster just beneath the surface of the ground. Sweet potatoes are reproduced from sprouts from the roots or from cuttings of the vines, and not from seed.

573. Varieties. The varieties that are commonly grown in the more northern states are of the Jersey type, including the Big Stem, Yellow, and Red Jersey varieties. The potatoes are rather short and thick, with light yellow flesh, which is likely to be rather dry, especially late in the season. In

Figure 141.—Five varieties of sweet potatoes: 1, Black Spanish or "Nigger Choker;" 2, Long, cylindrical type; 3, Jersey group, spindle shape; 4, Red Bermuda; 5, Southern Queen. The last three are most desirable in shape.

the South, the "yam" type of sweet potato is the more popular. The varieties of this type are much sweeter and moister than those of the Jersey type; the flesh may be light yellow, orange, or mottled. The individual roots are usually short and thick, though they may be very slender in some varieties. The most popular varieties of the yam type are Southern Queen, Georgia, and Red Bermuda.

574. Importance. The area devoted to sweet potatoes in the United States averaged 1,011,000 acres in the five years from 1918 to 1922, with an average production of 99,433,000 bushels. As the crop requires at least four and

one half months without frost for its growth, with plenty of warm weather both day and night, its culture is confined largely to the Southern states, though it may be grown for home use as far north as southern New York and from there westward to Iowa and Nebraska. Sweet potatoes are grown principally in the South Atlantic and Gulf states, the leading states being Alabama, averaging 131,000 acres, producing 12,383,000 bushels; Georgia, with 137,000 acres; Mississippi, 101,000 acres; North Carolina, 98,000 acres; and Texas, 96,000 acres. Among the other districts where the crop is grown on a large scale for market are New Jersey, eastern Maryland and Virginia, and near Merced, California.

575. Soils and Fertilizers. The best soil for sweet potatoes is a sand or sandy loam with a clay or clay loam subsoil. The loose surface soil allows the roots to develop, while the heavy subsoil retains the moisture and prevents the formation of long slender roots which are not marketable. Soils of this nature tend to produce the rather short, spindle-shaped potatoes so much desired for the market, of the type shown at the center in Figure 141. The sweet potato will grow in very poor soils, though it will yield better in those of moderate fertility. The lands should be rich enough to produce a good growth of vines and foliage, but too much manure or too rich soil will tend toward the production of a heavy top growth with only a few small, undesirable potatoes. The quantity of commercial fertilizer which is ordinarily used is small, only from 200 to 500 pounds to the acre. The use of crimson clover or some other legume in the rotation is desirable to furnish the necessary vegetable matter in the soil.

576. Growing the Plants. Sweet potatoes are ordinarily grown from sprouts from the roots rather than by planting the roots themselves in the field, though this latter practice is followed to some extent in the South. The usual plan is to start the plants in a bed of warm soil or in a hotbed and remove them for setting in the field as they become large

enough. As the roots continue to send up shoots for some time, a comparatively small number will produce sprouts enough for a considerable area. Half a bushel of seed will supply 1,000 good plants at the first pulling. The best plants are usually produced in a moderate hotbed from

Figure 142.—The type of sweet potato plants suitable for setting.

roots buried about 3 inches deep in leaf mold or rather loose earth. Before setting in the field, the plants should be pulled carefully from the bed and bunched in baskets or boxes. They will keep much better if they are "puddled" by dipping the roots in a thin mud of clay and water, but the tops of the plants should be kept dry. Sweet potatoes may also be propagated from cuttings of the vines, which root readily. If only a few plants are wanted for home use, it is often easier and cheaper to buy the plants than to grow them.

577. Preparation of the Soil. The right type of soil for sweet potatoes is easily prepared. It should be plowed some

time previous to give it time to settle, and disked and harrowed sufficiently to put it in good tilth. As good drainage is essential to success, ridge culture is practiced if the land is not naturally well drained. Planting on flat or unridged land is less expensive and just as satisfactory unless drainage is needed. The ridges, which should be 3½ or 4 feet apart, may be made by throwing furrows together with a plow. This preparation should be made long enough before planting to allow the land to become firm again. Just before the plants are set, a light harrowing will put the land in good condition. It should then be gone over with a marker which indicates the rows (if the land is not ridged), and the distances at which the plants should be set in the row. For level culture, the plants are usually set about 2 feet apart each way, though they may be 2½ by 2 feet or even 2½ by 2½ feet. Plants are usually set about 16 or 18 inches apart when planted in ridges. It is not necessary to mark the rows if a transplanting machine is used.

578. Setting the Plants. The plants should not be set in the field till all danger of frost is past. The setting may be done by hand or with a transplanting machine. If the plants are to be set by hand, the work can be hastened by opening a shallow furrow down the line of the ridge or along the mark. The principal things to observe in setting are to have the roots and the soil moist and to press the earth firmly about the plants. Planting as soon as the ground can be worked after a rain or putting about a half pint of water in each hole will help materially in getting a good stand. Only strong, well-rooted plants should be set.

579. Cultivation. The cultivation of sweet potatoes is not different from that given to most other cultivated crops. The surface of the soil should be stirred often enough to prevent the growth of weeds and to hold the soil moisture. One or two hoeings may be necessary to remove the weeds from the rows. Shallow cultivation should be given after

each rain till the vines cover the ground quite completely, when the field should be "laid by" by throwing some earth toward the row at the last cultivation.

580. Digging. Sweet potatoes should be dug before frost, as they are easily injured. If the vines freeze before they are dug, they should be cut away at once to prevent the frozen sap from going back into the roots. The potatoes are usually plowed out, a rolling coulter being used to cut the vines. Care should be used in harvesting and marketing to avoid injury to the potatoes. The ordinary potato digger is quite likely to bruise them, and a bruised sweet potato does not keep long. The potatoes are usually picked up by hand and carried to the packing shed for grading. Those which are to be shipped some distance are generally packed in ventilated barrels, while those which are marketed near by are sold in baskets or crates. For winter storage, a dry room or cellar maintaining a temperature of 35 degrees F. is best.

581. Uses. Sweet potatoes are ordinarily used as food for man, and may be prepared for the table in many ways. They form one of the principal articles of food throughout the South, where they are much more generally used than are white, or Irish, potatoes. The vines have some slight value as feed for stock, and some of the coarser varieties of potatoes are grown for feeding to hogs and other animals. When these varieties are grown for hog pasture, they are not dug, but the hogs are turned in and allowed to root out the potatoes. While they grow well on this food, the hogs must be given some corn in order to fatten them.

LABORATORY AND FIELD EXERCISES

1. Obtain at least 100 potatoes of some standard variety and select from them the 10 that best represent the variety. Compare these with any that show signs of running out as indicated by elongation and pinching up of the seed end.

2. If possible, obtain a sample of potatoes affected by internal brown rot. Cut open several tubers to become familiar with the effect of the disease and to learn to identify it.

3. Obtain 10 pounds of medium-sized, smooth, shallow-eyed potatoes, and 10 pounds of rough, deep-eyed potatoes. Carefully pare both samples, noting the time required and the appearance. Weigh the pared potatoes of each sample. What was the percentage of waste in each and what was the difference in time required to peel the two samples?

4. Dig 100 hills of potatoes in a field where all hills were grown under as nearly uniform conditions as possible. Note the weight, uniformity, character, and proportion of marketable tubers in each hill. What would be the yield and value of an acre of potatoes planted in the usual way if all hills were like the best? If all were like the poorest?

5. Set stakes beside hills of growing potatoes on which the foliage has been destroyed by bugs or blight, and by others with foliage uninjured. At digging time note yields from the marked hills. The results will emphasize the importance of spraying.

6. Obtain three potatoes of about the same size of each variety commonly grown in your community. Put them all in a uniformly heated oven and bake until one variety is well done. Remove all potatoes and examine as to baking and quality. Is there any reason why buyers prefer a car of potatoes of one variety to a car of mixed varieties?

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CHAPTER XXIII

SUGAR PLANTS

582. Introduction. The two leading sugar plants of the world are the sugar beet and sugar cane. Sugar cane has been cultivated for many centuries. The development of the sugar-beet industry dates back little more than a hundred years. The cultivation of sugar cane is confined to the tropical and semitropical portions of the world. The sugar beet is a plant which normally succeeds best in temperate climates. The production of both cane and beet sugar has increased enormously in the past twenty years, reaching its maximum in 1913-14, when the estimated sugar production of the world was 20,704,000 short tons. Of this, 11,270,000 was cane sugar, and 9,434,000 tons was beet sugar. The production of cane sugar usually considerably exceeds the production of beet sugar.

THE SUGAR BEET

583. History and Description. Reference has already been made to the sugar beet in the chapter on root forage crops. It is one of the several forms of *Beta vulgaris*, of which the mangel is another. The sugar beet is a broad-leaved plant with a long taproot. The upper part of this root and the base of the stem are thickened. The root is broadest a little below the crown and tapers very gradually, as shown in Figure 143. The flesh and skin of the sugar-beet root are white, and the root grows almost entirely below the surface. A good root weighs from 1 to 1½ pounds, and contains about 20 per cent of solids, of which about four fifths is sugar. The plant is a biennial; seed is produced by storing the roots over winter and setting them out the following spring.

The development of the beet as a sugar-producing plant dates to about 1800, when German chemists began to experiment in the production of sugar from plants which could be grown in temperate climates. The increase in sugar content of the beet root from 6 to about 16 per cent is the result of careful breeding. The beet-sugar industry has been and is

Figure 143.—Sugar beets of the most desirable type.

an immensely valuable one in Germany and other European countries, and it is rapidly developing in the United States.

584. Importance. Of the 8,757,000 tons of beet sugar produced in the world from the 1914-15 crop, 6,469,000 tons, or nearly three fourths, were produced in Germany, Russia, and Austria-Hungary. The development of the beet-sugar industry in the United States is of comparatively recent date. It was not till 1906 that the production of sugar from beets in this country exceeded that from sugar cane. In 1900, the production of beet sugar amounted to 76,589 long tons, while that of cane sugar was 278,470 long tons, or nearly four times as much. In 1910, the production of beet

sugar had reached 450,000 tons, while that of cane sugar was 311,000 tons, only about two thirds as much. In 1922, the production of beet sugar was 691,000 short tons, and of cane sugar only 242,000 tons. The average area of sugar beets harvested in the United States for the five years from 1918 to 1922 was 702,000 acres, with a production of 6,497,000 tons of beets, from which 1,714,800,000 pounds of sugar were made. In the past ten years the area devoted to the crop has increased from 515,000 acres in 1914 to 978,000 acres in 1920, the production of sugar from 1,144,000,000 pounds to 2,178,000,000 pounds, and the number of factories from sixty to ninety-seven.

Colorado was the leading state in production in 1921, with fifteen factories and 590,000,000 pounds of sugar. California was second with 342,000,000 pounds, Utah third with 312,000,000 pounds, Michigan fourth with 244,000,000 pounds, and Nebraska fifth with 105,000,000 pounds. In addition, there were 26 other factories in other states, scattered from Ohio to Washington and Oregon, with a total production of 222,000,000 pounds. The area of sugar beet production in this country is capable of wide extension, while for sugar cane it is comparatively limited.

585. Culture. The culture of sugar beets differs little from that of mangels (Section 526). The crop grows best in a loam or sandy loam soil. Good preparation is essential, as the seed is rather slow to germinate. The land should be as free as possible from weeds, because the heaviest expense of production is for cultivation. The seed is ordinarily sown with a beet drill which sows several rows at a time. The usual distance between the rows is from 20 to 28 inches. Where the crop is irrigated, the beets are often sown in double rows 1 foot apart, with a space of from 24 to 28 inches between each pair of rows. To insure a full stand, 20 pounds of seed to the acre is required. Seeding should be done early in May.

Cultivation should be begun as soon as the rows can be followed, and continued at intervals of six or eight days until the tops meet between the rows. A special cultivator which cultivates several rows at a time is in common use. In order to obtain a perfect stand and prevent crowding, the plants must be thinned at about the time the fifth leaf is produced. They are bunched and then thinned by hand in the same manner as already described for mangels, except that the distance between the plants is about 8 inches. The beets should be harvested before danger of frost in the fall, and should be protected from freezing. The tops are ordinarily twisted off by hand and the beets thrown into piles, from which they are hauled to the sugar factory or shipping station. The tops are usually cured for feeding to cattle or other stock. If they are not needed as forage, they should be spread on the land as fertilizer.

The highest percentage of sugar is produced when there is plenty of moisture, particularly during the early growth, with abundant sunlight. These conditions are found most commonly in the irrigated districts of the Rocky Mountain and Pacific states, though the Northern states generally present favorable conditions for the growth of sugar beets.

586. Production of Beet Seed. Sugar beets for seed production are selected by taking small samples out of the side of the root with a trier and determining the percentage of sugar they contain. Only those which show the proper sugar content are retained for planting. The hole made by the trier should be filled with charcoal or clay to prevent decay. The roots should be stored over winter in sand in a dry cellar or pit, tested the next spring for sugar content, and then planted in rows in the field to produce seed. From three to five roots are required to produce a pound of seed. Eighteen to twenty pounds of sugar beet seed per acre is sufficient for a good stand. A large part of the sugar-beet seed sown in the United States is now produced here.

587. The Manufacture of Sugar. After the beets reach the factory, they are washed and trimmed, and are then cut into long strips called "cossettes." The juice is then extracted from these cossettes by means of hot water, leaving the by-product known as beet pulp. A small quantity of lime is then added to the juice; the impurities combine with

Figure 144.—A mill for the manufacture of beet sugar. This factory has a capacity of 15,000,000 pounds of sugar a year.

it and solidify, and are removed by filtering. The purified juice is then boiled down; when it thickens sufficiently, it is placed in pans within a vacuum and boiled until the sugar crystallizes. The grains of sugar are now separated from the molasses by placing the "mass-cuite," as the product is called as it comes from the vacuum pans, in a centrifugal machine lined with fine sieves. The whirling action of the machine drives the molasses through the sieves and the sugar is retained. The wet sugar is heated to drive off the extra moisture, after which it is ready for market, while the molasses is again boiled in the vacuum pans until the sugar it contains crystallizes. This second sugar or mass-cuite is dark in color, and is mixed with fresh juice to lighten it. It is then boiled again in the vacuum pans and the sugar extracted. The molasses from the second boiling is used for stock feed.

588. By-products and Their Value. Beet pulp, the cossettes or strips of the beet roots from which the sugar has been extracted, contains about 90 per cent of water and 10 per cent of solids, so that it is nearly equal to mangels in feeding value. The pulp is relished by dairy cows, and makes an excellent substitute for corn silage. If it is combined with clover or alfalfa hay when fed to beef cattle or sheep, comparatively little grain is required. Toward the close of the feeding period, grain should gradually be substituted for the beet pulp, finishing the fattening on hay and grain without pulp. Dried beet pulp is supplied by some factories. This keeps much better than wet pulp and is much lighter to handle, one pound of it being equal in feeding value to about eight pounds of wet pulp. Beet molasses alone is not palatable, but it is often mixed with pulp before drying, the dried molasses beet pulp being about equal in feeding value to the dried pulp without the molasses. Beet molasses is also mixed with chopped hay or straw for feeding to stock.

SUGAR CANE

589. History and Character. Sugar cane, *Saccharum officinarum*, is a perennial grass growing from 8 to 15 feet high, with solid, heavy stalks like corn. The flowers are in silky, plume-like terminal panicles, but seed is seldom produced. The plant is grown for the juice which the stalks contain, and from which sugar and molasses are made. Sugar cane has long been cultivated in tropical countries, and until quite recent years was the principal source of sugar. It is probably a native of southeastern Asia or some of the adjacent islands.

590. Sugar Content. The sweet, or saccharine, matter is confined to the stalks and is greatest near the middle, decreasing at the ends, but more particularly near the top. For this reason it is most profitable to save the upper portions of the stalks for replanting, though sometimes the whole

cane is used. The saccharine content and the purity of the juice depend on the soil, the climate, and many other factors. The stalks consist of fiber and juice. A large proportion of fiber naturally means a low sugar content, hence stalks with short joints are undesirable on account of the extra fiber they contain. Dry seasons also lower the sugar content, because the joints are shorter and the juice more scanty. In order to insure a plentiful supply of water, the crop is quite commonly irrigated.

591. Countries Which Produce Sugar Cane. The production of sugar cane is confined entirely to tropical and semitropical regions, as the crop requires a long, hot season with plenty of moisture for its best growth. The world's production of cane sugar in the five years from 1916 to 1920 was about 13,786,000 short tons of 2,000 pounds each. Of this enormous quantity, by far the greater part was produced by North America and Asia, the former averaging 5,964,000 tons and the latter 5,777,000 tons. Cuba, with an average of 4,123,000 tons, is the greatest single producer. British India ranks next, with 3,101,000 tons. The only other country producing sugar on a similar scale is Java, with an average of 1,700,000 tons. South America averaged 1,122,000 tons in the five-year period, most of the production being in Argentina, Brazil, and Peru. Africa contributed 592,000 tons to the world's total and Australia and Fiji 320,000 tons. The production of the continental United States was only 222,000 tons, most of this being grown in Louisiana. Sugar cane is grown in small patches for the production of sirup in all the Southern states. where it is locally known as "ribbon" cane.

592. Propagation. Sugar cane is propagated from sections of the stalks. When these sections are planted, new stalks grow from the buds at the base of each leaf. There is considerable difference in the freedom with which different varieties grow from these buds; some grow from buds any-

where on the stalk, others only from those near the top. The cane is usually cut into sections containing one or more buds, but sometimes the whole cane is planted. As the food stored in the stalk is used by the young plant till it becomes established, it is desirable to have the stalk in as good condition as possible. The canes of some varieties are very brittle and crack readily when cut, allowing disease and decay to enter, hence the entire stalk is planted to avoid this loss. The tops are best for propagation, as they grow most readily and crack less.

In sections where frosts do not occur, the crop can be grown from the old stools for several years by splitting them into sections with a sharp plow or a tool specially devised for the purpose. In the southern United States, it is necessary to protect the canes from frost by cutting them in the fall and storing them over winter in a moist, cool place. The location should not be wet enough to cause the stalks to rot, nor cold enough so that they will freeze. The stalks are usually laid in piles and covered with the leaves which have been stripped from them. Sometimes they are laid in windrows between the rows from which they were harvested and covered by plowing furrows upon them. In this case, the leaves are left on. This method of storing is satisfactory only in favorable seasons. In wet or cold years, it is quite likely to result in severe loss of the seed canes. The seed canes should be selected from places where the growth is good and which are as free as possible from disease.

593. Soils and Fertilizers. Ordinary good soil is suitable for the production of sugar cane. The land should be well drained, but should be so situated that it can be irrigated readily. When the rainfall is very heavy, irrigation may be unnecessary, but it is well to provide for it in case of need. Open ditches are ordinarily used for drainage. The land should be plowed very deep, the deeper the better, even up to 20 or 24 inches. Traction plows are quite gen-

erally used in plowing, as the work is too heavy for horses. Quite frequently, however, large mules are used in preparing the land and cultivating the crop. The demand for the largest and best mules on the sugar plantations is so great that they are commonly known on the market as "sugar mules." After the plowing is done, good surface tillage is given till planting time. Stable manure is the best fertilizer, but it is not often available in large quantities. As most of the potash and phosphorus removed by the crop is returned in the ashes and waste from the sugar mills, nitrogen is the only element of fertility which it is necessary to purchase in quantity. Sugar, the only product removed, is composed of carbon and water, hence it takes nothing from the land. Nitrogen is lost in the burning of the stalks and leaves.

594. Planting. Sugar cane is planted by laying the stalks in furrows from 4 to 6 feet apart. If the seed canes are in good condition, 2 feet apart in the row is thick enough to plant the pieces of stalks to obtain a good stand; if its condition is poor, thicker planting is necessary. The ordinary method is to lay the cane horizontally in the furrow and cover it with a small plow or cultivator. Sometimes the crop is planted in hills by sticking the sections of stalks diagonally into the ground with the upper end slightly above the surface, while, if particularly quick germination is wanted, they are planted upright with the buds above the surface.

595. Cultivation. Sugar cane is cultivated frequently to keep it clean of weeds and to insure rapid growth. As it is not planted in check rows, it is usually necessary to do some hand hoeing to remove the weeds within the rows. The cultivator used is usually of the toothed or shovel type, though in recent years disk cultivators have come into favor in some sections. Cultivation is continued till the ground between the rows is entirely shaded by the crop.

596. Harvesting. The total sugar content of the stalk increases up to a certain stage of ripeness, which can only

be determined accurately by chemical analyses of sample stalks. Naturally, it is important to harvest when the stalks contain the maximum quantity of sugar. Though chemical analysis is more certain, the grower learns to determine the best date for cutting quite accurately by the appearance of the stalk and the stage of growth. For economy of production, it is desirable to continue the operation of the sugar mill over as long a period as possible. As the sugar content decreases quite rapidly after the maximum is reached and after the cane is cut, planters extend the season by planting varieties which ripen at different times, by planting on different types of soil, or by extending the planting season over a considerable period.

The usual method of harvesting is to strip the canes and cut them off close to the ground with a knife. Machines for harvesting have been devised, but they have not proven satisfactory. As the canes begin to lose their sugar rapidly within 24 hours after cutting, they are usually hauled from the field to the mill as soon as cut. Numerous methods of transportation are in use, including boats, wagons, and tramways. One of the most common methods in large fields is the use of a light, movable track with cars drawn by a small steam engine. The cane is usually loaded upon wagons by hand; it is then loaded into the cars by the use of a derrick and is unloaded in the same way at the mill.

597. Extracting the Juice. The juice is extracted from the stalks by means of heavy rollers. The stalks are first shredded by revolving cylinders set with numerous pegs or spikes, and then pass between rollers which crush out about 75 per cent of the juice. They then pass on to another set of rollers, on the way to which they are sprayed with the heated juice from the third and last set. The second set of rollers removes about 10 per cent of the juice, and the stalks then pass to the third set. On the way, the canes are sprayed with hot water. The third set of rollers crushes out about

5 per cent of the total juice. The crushed stalks (bagasse) are then carried on a conveyor to the furnaces. Ordinarily, the bagasse supplies sufficient fuel to run the mill.

598. Making the Sugar. The methods of manufacturing cane sugar are not very different from those already described for beet sugar. The juice is first heated and then purified by the addition of milk of lime, after which it is skimmed and filtered to remove the solids which have united with the lime. This refuse is returned to the fields as fertilizer, as it contains a large part of the phosphorus and potash removed by the crop. After it has been purified, the juice is concentrated by boiling in a series of vacuum pans and is finally crystallized in a larger pan of the same kind. The sugar is then dried and packed for market. The by-products of manufacture and the various grades of sugar, sirup, and molasses are little different from those made from sugar beets.

LABORATORY AND FIELD EXERCISES

1. A few sugar beets may be grown in different plats of different soils and with different fertilizers on the same soil. Write out the results fully and carefully. Show how many pounds could be raised on an acre under each condition, if the plat average were maintained.

2. Those who are interested in the production of sugar cane should visit a cane mill, if possible, and become familiar with its various processes and products.

3. Does your community and your state produce as much sugar as it uses?

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CHAPTER XXIV

FIBER PLANTS

599. Classes of Fibers. The fibers we use are obtained from two general sources, animal and vegetable. Only two kinds of animal fiber are in common use, wool and silk, but there are numerous classes of vegetable fiber. The usual definition of the word "fiber" makes it include not only the material used for spinning, but also that used for upholstering, weaving, and the making of paper. A classification of fiber according to use, as made by the Office of Fiber Investigations of the U. S. Department of Agriculture, includes spinning fibers, tie materials, natural textures, brush fiber, plaiting and rough weaving fiber, various forms of filling, and paper material. Of these, the most important are the spinning fiber and paper material. Spinning fiber includes all grades from those made into the finest thread to the largest ropes. It is only the class of plants used principally for the production of spinning fiber that will be considered here, though these plants may also be used for several of the other purposes mentioned.

600. What Spinning Fiber Is. Fibers, or wood cells, are an important part of all plants. The young, growing parts of plants are made up of soft-walled cells which have little strength and soon decay when removed or when the plant dies. The cells of the older and more permanent parts have thick, tough walls, and are of two kinds. One kind is placed end to end without partitions, forming continuous channels or ducts through the stems and other parts of the plant, thus providing for the movement of water and plant food. The other is the wood fiber cells, which are elongated, spindle-shaped, and overlap each other so as to form a continuous

bundle. These cells make up what are known as the fibro-vascular bundles, which give strength and stability to the plant. The woody parts of trees and shrubs are made up of these bundles, as are also the fibrous portions of the stems of annual plants. Some plants produce simple cells on the surface of the seeds and other parts, which are called surface fibers and are sometimes of value for textile purposes.

The more important textile fibers are either bast fibers, from the inner bark of such plants as flax and hemp, or surface fibers, from cotton. In addition, some textile fiber is obtained from the leaves and leaf-stems of certain plants, such as sisal and manila hemp. By far the most important of the plants which produce spinning fiber is cotton. The only others which are grown in the United States to any extent are flax and hemp, and flax is grown almost entirely for seed.

COTTON

DESCRIPTION AND CLASSIFICATION

601. Origin and History. The most important species of cotton, the ordinary upland type grown in our Southern states, is supposed to be a native of southeastern Asia. Its general cultivation is of comparatively recent date, as it has been grown in China for only ten or twelve centuries, while its cultivation within the United States dates back but a century and a half. The importance of cotton as a fiber plant was decidedly limited, on account of the difficulty of separating the fiber, or lint, from the seed, till the invention of the cotton gin in 1792 by Eli Whitney, an American. Before that time, it had been grown to some extent in Egypt and India, but had never been a serious competitor of wool and flax. The Indians of tropical America cultivated cotton at the time of the discovery of the New World, but they made little use of it. While it was introduced into the Southern states before the Revolutionary War, its cultivation did not become general there till after the beginning of the nine-

teenth century. Since that time the growth of the industry has been rapid. (Section 607.)

602. Botanical Description. Cotton belongs to the *Malvaceae,* or mallow, family, and is the only member of that family which is an important cultivated plant. There is a number of species of cotton, ranging in form from bushy herbs to trees. They are all natives of tropical regions and are probably all perennials, though the cotton which is grown in the United States has been developed into an annual.

The ordinary upland cotton, of which by far the greater part of the crop consists, is *Gossypium hirsutum.* It is a vigorous annual plant, with a branching, upright stem and a taproot with numerous lateral branches. The depth to which the taproot penetrates varies greatly in different soils. In sandy soils it may reach a depth of 2 feet or more, while in heavy clay it may be only a few inches long or almost entirely lacking. The laterals or feeding roots are only a few inches below the surface. The stem grows from 2 to 6 feet high, according to the variety, the soil, and the season. The usual height is from 2½ to 3½ feet. The length and number of the branches and the length of the internodes, or "joints," depend on the same factors as the height of the plant.

The leaves of cotton are alternate, from 3 to 6 inches long, with a width slightly less than the length, the lower ones heart-shaped, the upper more or less three or five-lobed. The flowers are large and showy, being from 3 to 4 inches across. They are white when they first open, but turn rosy pink on the second day, so that a field in bloom is very attractive. Cotton is commonly open-pollinated.

The fruit, or "boll," is enclosed by leafy bracts when small, and is then commonly known as the "square." It finally develops into a pointed, somewhat egg-shaped body, about the size of a small hen's egg, closely packed with seeds

and lint. It is composed of three to five cells. When ripe, the boll turns brown and the cells separate along the central axis and also split down the back, so that the lint and seeds are exposed. The seeds, which are about three eighths of an inch long and half as wide, are thickly covered with lint and fine fuzz. The lint, which is the cotton of commerce, is from seven eighths to one and one half inches long in the ordinary varieties, the fuzz, or linters, one fourth inch or less. The seed consists of a thick seed coat, or hull, and an oily yellowish-white kernel.

603. Other Species. Sea Island cotton, *Gossypium barbadense*, differs from the ordinary type in that it grows taller, has longer branches, yellow flowers, longer and finer fiber, and seeds free from fuzz. It is grown in the West Indies and on the islands and lower lands along the coast of the Carolinas and Georgia. Egyptian cotton is generally regarded a variety of *G. barbadense*. It has a long, strong fiber and is very similar in many ways to Sea Island cotton. It is grown largely in Egypt, and has recently been grown successfully under irrigation in Arizona and southern California. India cotton, *Gossypium herbaceum* has more slender stems than the ordinary upland type, leaves with rounded lobes, and smaller, less pointed bolls. The lint may be white, yellow, or brown. Its cultivation is confined to southern Asia.

604. Cotton Fiber, or Lint. The cotton of commerce is the lint, or surface fibers, with which the seed is covered. The individual strands or fibers consist of single cells, ranging from ½ to 2½ inches long in the different varieties. Each fiber or cell is much twisted, a feature which distinguishes it from other fibers. It is estimated that there are sometimes as many as five hundred twists to the inch. The fiber is very strong for its size and can be woven into a very fine thread, though not as fine or as strong as silk. The value of the lint depends on its color, cleanness, length, and strength.

The importance of cotton as a textile material is due largely to its cheapness and durability.

Ordinary varieties of upland cotton yield about 1 pound of lint to each 3 pounds of seed cotton; that is, 3 pounds of seed cotton will yield one third, or 33 per cent, of its weight in lint. The usual variation is between 30 and 35 per cent, though nearly 40 per cent is occasionally obtained. Sea Island and Egyptian cotton yield rather less, only about 30 per cent. Long-staple upland, a type with specially long, strong lint, yields less lint than ordinary upland, but the value per pound is much greater.

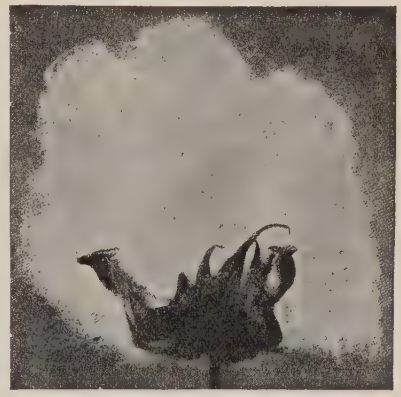

Figure 145.—An open cotton boll ready for picking.

605. Varieties. The varieties of cotton are numerous, probably as many as two hundred names being known in the United States, though not all represent distinct varieties. They differ in length of lint, earliness, productiveness, size of boll, and other features. The principal classes are the short-limb, or King, type, the big-boll type, and the long-staple type. The productiveness and earliness of cotton depend to a considerable extent on the length of the internodes and the length of the branches. The limbs appear in the axils of the leaves along the main stem and the flowers are produced on the secondary branches which grow from these main limbs. A type of plant with limbs close to the ground and with short joints is ordinarily earlier and more productive than one with fewer and longer limbs.

The King type is early in maturing, is short-limbed, and produces small bolls. The big-boll type grows larger and ranker, the bolls are larger, and the crop is later in maturing. Long-staple cotton produces uniformly longer and more valuable lint than the ordinary upland varieties. The small-bolled cottons pick easily but are readily damaged by storms, as the outer covering of the boll, the "burr," is thin and curls backward as the boll opens, exposing the seed cotton and giving it little support. On the other hand, the burr of the big-boll type remains flat and supports the seed cotton so that it is not easily dislodged. Among the better known varieties of the small-boll type are the Welborn, Peterkin, and King, while the big-boll, or storm-proof, type includes Russell, Truitt, Triumph, Rowden, and Jones Improved. The best known of the long-staple varieties are Allen, Griffin, and Cook.

IMPORTANCE OF THE CROP

606. Importance of the Crop. Cotton is not only the most important textile plant of the world, but it is one of the most important of the world's crops, for it furnishes many valuable products in addition to the lint from which cotton fabrics are made. The world's production of cotton ranges from 17,000,000 to 21,000,000 bales, or about 8,000,000,000 to 10,000,000,000 pounds of lint annually. The average annual production for the five years from 1916 to 1920 was 17,747,000 bales, of which nearly two thirds was produced in North America, about one fifth in Asia, and about one fourteenth in Africa. Practically the entire crop of North America was produced in the United States, the average annual production for the five years being 11,931,000 bales. India ranks next to the United States in the production of cotton, with a crop of 3,800,000 bales; Egypt follows with about 1,200,000 bales. No other country except China is an important factor in the production of cotton.

607. Production in the United States. The increase in the production of cotton in the United States since the beginning of the nineteenth century is one of our most remarkable records of progress. There has been a continual increase in the production of cotton since 1800, except in the decade from 1861 to 1870, when the war between the states practically demoralized the cotton industry of the South. The crop of 1864 was less than 300,000 bales, though five years previous the production reached 4,500,000 bales. In the decade from 1870 to 1880 there was a gradual recovery in the industry, the average production being more than 4,000,000 bales. Since then, the increase has been about 2,500,000 bales annually for each decade.

Figure 146 shows that the production of cotton is confined almost entirely to the Southeastern states. The average area in cotton from 1918 to 1922 was 33,941,000 acres. The annual production of the United States was 10,964,000 bales, and the average annual value of the crop about $1,293,669,000. Nearly one third of the cotton acreage of the United States is in Texas. This state produced more than

Table XX. Average acreage, acre yield, total production, and farm value of cotton in the ten leading states and in the United States during the five years from 1918 to 1922, inclusive.

State	Area	Acre yield	Production	Farm value December 1
	Acres	*Pounds*	*Bales*	*Dollars*
Texas	11,295,000	131	3,126,000	354,498,000
Georgia	4,620,000	134	1,342,000	169,822,000
South Carolina	2,686,000	203	1,181,000	142,730,000
Arkansas	2,784,000	169	985,000	113,170,000
Mississippi	2,928,000	159	981,000	121,653,000
North Carolina	1,541,000	265	856,000	99,960,000
Oklahoma	2,666,000	145	809,000	86,526,000
Alabama	2,653,000	130	718,000	85,701,000
Louisiana	1,407,000	129	382,000	44,837,000
Tennessee	828,000	195	333,000	38,047,000
All others	533,000	224	251,000	36,725,000
United States	33,941,000	153	10,964,000	1,293,669,000

one fourth of the cotton crop of the country and more than 15 per cent of that of the entire world. Georgia, South Carolina, Arkansas, and Mississippi ranked next in the order named. In addition to the states shown in Figure 146 and in Table XX cotton is produced in Virginia, Florida, Missouri, Arizona, and California. The average acreage, yield per acre, total production, and value of cotton in the ten leading States during the five years from 1918 to 1922 are shown in Table XX.

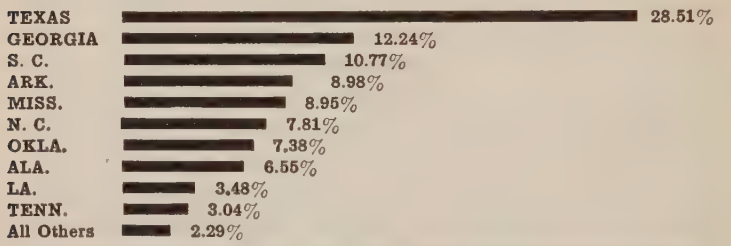

Figure 146.—Percentage of the cotton crop produced in each of the states of largest production, 1918-1922.

More than two fifths of the improved land in farms in South Carolina and about one third of that in Texas, Georgia, Arkansas, and Mississippi is devoted to cotton. About 6.8 per cent of the improved farm land in the United States is planted to cotton, though its production is practically confined to the ten Southeastern states. The total acreage of oats, a crop which is grown to some extent in every state, is about one fourth larger than that of cotton, while the acreage in wheat is almost double the cotton acreage. Corn is grown on more than three times as much land as cotton.

The average annual yield per acre for the entire United States for the period from 1918 to 1922 was 151.3 pounds. The lowest acre yield, 159 pounds, was that of Louisiana, while the highest yield in the ten important states was shown by North Carolina, 265 pounds. Of the annual crop of nearly 22,000,000 bales, about half is exported.

SOILS AND FERTILIZERS

608. Soils Adapted to Cotton. The best crops of cotton are produced on the rich alluvial loams of the Mississippi Valley and the heavy clay loams of Texas. Cotton grows well, however, on a wide variety of soils, from the sands and light loams of the Carolina coast to the closest and stickiest of clay soils. Its growth and productiveness are largely influenced by the physical character of the soil and its fertility, and by the available supply of moisture. On rich, wet land a very heavy growth of stalks and leaves is produced, often at the expense of seed production, so that the yield of lint may be less than on less fertile or on drier land. On the average, the largest yields of lint are produced on clay and alluvial loams with a moderate rainfall.

609. Fertilizers and Manures. Because cotton is grown on so large a proportion of the cultivated land of the Southern states and because no regular rotation is generally followed, this crop is often planted on the same field for several years in succession. This practice, however, is much less common now than it was a few years ago. On account of the constant growing of the same crop on the land with little or no effort to keep up the supply of vegetable matter and plant food, many of the fields are now more or less exhausted, so that they must be fertilized highly to produce a good crop. Whenever possible, a regular rotation should be followed which includes a leguminous crop to supply nitrogen. A number of excellent crops for this purpose are available, including the cowpea, soy bean, crimson clover, and velvet bean. Increasing the supply of vegetable matter and adopting a proper system of crop rotation are the most effective methods of increasing cotton yields.

When the nitrogen is supplied by a leguminous crop which precedes cotton, less of this element need be added in the form of commercial fertilizers. The use of a complete fertilizer is advised in all cases when the soil shows a tendency

to become exhausted and when leguminous crops are not grown. Cotton seed was formerly largely used, but the ready market for it afforded by the oil mills has led to the substitution of other materials. As the oil in the seed is of no value as a fertilizer, the use of whole seed for this purpose is wasteful. A popular fertilizer normally is cottonseed meal, as it contains a good supply of nitrogen and some potash and phosphoric acid. It should generally be supplemented with acid phosphate and muriate of potash, if available, while a small quantity of nitrate of soda helps the early growth of the crop.

Barnyard manure is used to some extent for cotton, but the available supply is usually limited, as the number of live stock kept on Southern farms is relatively small and that which is kept is confined for only a small portion of the year, so that most of the manure is dropped on the pastures.

GROWING THE CROP

610. Preparation of the Land. The methods of preparing the land for cotton vary somewhat with different soils and in different sections, but the general plan is about as follows: The land is "bedded" early in the spring, that is, narrow beds are made by throwing together two furrows with a small plow, alternating with narrow unplowed strips. Where the land was in cotton or corn the previous year, the "bed" is made between the old rows. The stalks are either cut up with a stalk cutter or are gathered and burned. Bedding helps to aërate and warm the soil and the furrows give drainage, so that it is advisable on poorly drained land. Later, but before planting time, additional furrows are thrown upon these beds from each side, but the entire middle is sometimes not broken out till the first cultivation.

When commercial fertilizer is applied, it is either sown broadcast on the field before bedding, or it is distributed

along the rows and the beds thrown on it a week or ten days before planting. The latter practice is the more common one. It is sometimes sown in the furrows at the time of planting, though some of the fertilizers which are used are likely to injure the seed if they come in contact with it. Land is not always plowed before it is planted to cotton, though in recent years the practice of plowing and planting flat as corn is commonly planted has come into use in some sections. Fall plowing is frequently not advisable, on account of the loss from leaching or erosion. The growing of a winter cover crop on cotton lands is an excellent practice. When a cover crop such as bur clover or vetch is grown, the land is plowed early in the spring and the cotton is planted either without bedding or low beds are made a few days before planting. In nearly all cases, larger yields are obtained by plowing the land from 6 to 8 inches deep early in the spring and harrowing and disking it every few days till planting time than by the methods in common use.

611. Planting. The best grade of cottonseed which can be obtained should be used for planting. Good, heavy seed is just as important a factor in obtaining good yields of cotton as it is in corn or the small grains. The ordinary practice of taking the regular run of cottonseed as it comes from the gin, storing it with little or no attention over winter, and then planting heavily in the spring to assure a stand, is a bad one. While the extra seed has some value as a fertilizer, it is much more profitable to sell it and to use some other fertilizer.

Instead of taking the "gin-run" of seed for planting, the best portion of the field should be picked by itself each fall, preferably at the earlier pickings. This cotton should be ginned separately and the seed brought back to the farm for planting the following spring. The seed should be spread out in a thin layer to dry, as it heats readily when green and its germination is easily destroyed. After it is dry, it may be sacked or piled in bulk, if it is kept in a dry place. It should

be protected from the weather and from mice and rats. The quantity of seed which is now generally planted ranges from ½ to 1 bushel to the acre. While this is much more seed than is needed to produce a good stand, the numerous plants produced help to break the crust which often forms after heavy rains and which might prevent entirely the emergence of plants from thinner seedings. Up to a few years ago, it was the common practice to plant as much as 2 or 3 bushels to the acre, but the demand for the seed at the oil mills has led to the discontinuance of this waste.

The usual method of planting is to open a furrow in the middle of the bed with a small plow and to distribute the seed evenly in this furrow with a one-row planter. Attempts to plant cottonseed in hills have not been very successful, as the fuzz on the seeds causes them to stick together and prevent uniform dropping. Some attempts have been made to remove this difficulty by coating the seed with flour paste. This makes it possible to blow out the light seed with the fanning mill and to plant with the corn planter. It is probable that the plan of planting in hills as corn is usually planted will become much more general in the next few years. The distance between the rows ranges from 2½ to 5 feet, according to the variety and the fertility of the soil. A small, early variety of the King type on sandy soil may be planted much closer than one of the big-boll type on loam or clay soils. The seed is covered to a depth of from 1 to 3 inches, depending largely on the nature of the soil. The crop is planted during April and the first two weeks of May.

612. Cultivation. The ordinary method of cultivation has been to wait till the plants reach a height of 2 or 3 inches and then to break out the middles of the rows, which have previously been unplowed. A little later, the field is "barred off" by running a small plow or broad shovel close to the row and throwing the earth away from it. About this time, the plants are thinned with the hoe to the proper distance in

the rows, this process being known as "chopping out." The distance between the plants varies with the width of the rows and the fertility of the soil. Where the plants make only a small growth, they should be much closer together than where the growth is strong and rank. The

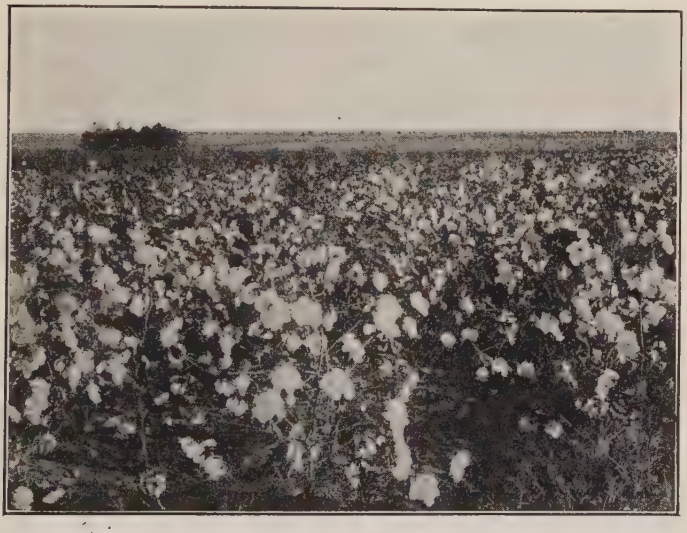

Figure 147.—Field of cotton ready for picking. Usually the first picking is made before so much of the crop has opened.

usual distance between the plants is from 1 to 2 feet. Later cultivation is usually shallow, for deep plowing cuts off many of the feeding roots. In some cases, however, particularly in weedy fields, the "turning plow," a small moldboard plow, is used for some of these later cultivations, often with disastrous results to the crops. From three to five cultivations and from one to three hoeings are ordinarily given.

Better cultivation is now generally given to the cotton crop than was the case a few years ago. Two-horse cultivators are replacing the one-horse ones so long in use, and the harrow and the weeder are more generally used early in

the season. These tools pull out some of the young plants, but usually they are much thicker than is necessary and those that are pulled out with the harrow will not have to be hoed out later. At the same time large numbers of young weed and grass plants are killed, and the labor of later cultivations is lessened. Thin planting obviates much of the work of chopping out, and the frequent use of the cultivator makes hand hoeing largely unnecessary. Shallow cultivation with flat blades or with small shovels is taking the place of deeper cultivation with large shovels or the turning plow. Cultivation is now continued practically up to the time the bolls begin to open. In this way, the crop is kept growing throughout the season, weeds are prevented from seeding, and the supply of moisture is maintained.

HARVESTING THE CROP

613. Picking. As soon as a considerable number of the bolls have opened, picking is begun. This operation usually begins in the extreme south about August 15, while farther north it may be delayed till September 15. Picking must be done by hand, as no satisfactory machine for the purpose has yet been produced, though many attempts have been made to invent such a boon to the cotton producer. The main difficulty with a mechanical picker is that the crop ripens over a considerable period of time and all of it can not be picked at once. The mechanical picker injures the plants if it is used when they are yet growing, while, if the cotton is left in the field till the end of the season, much of it will be damaged by the weather.

When the boll opens, the lint is easily dislodged by a slight pull with the hand. Men, women, and children are all engaged in the work of cotton picking. The lint is placed in sacks or baskets as it is picked, and as these are filled they are emptied into wagons to be hauled to the gin. In order to gather all the crop in the best shape, three pickings are

usually made, the first as soon as the earlier bolls open, the second when the majority of the bolls are ripe, and the third after frost has stopped further growth. The number of pickings may be reduced to two or may be increased, according to the locality and the season. The bulk of the crop is usually gathered at the second picking. Picking is the most expensive part of cotton production, and the invention of a satisfactory machine to do this work would mean almost as much to the industry as the invention of the cotton gin.

614. Ginning. The next process after the cotton is picked is to separate the seed from the lint. The seed cotton is hauled to the ginnery, where the lint is removed from the seed and is packed into bales. The type of gin which is in common use, except in the Sea Island district, is the saw gin, which was invented by Eli Whitney in 1793, and has since been improved by many other inventors. The seed cotton is fed into a hopper at the bottom of which are many revolving saws mounted on a cylinder. These saws tear the lint from the seed, the seed dropping down into a chute and the lint being removed from the saws by sets of brushes on another revolving cylinder. The lint is then pressed against a board by means of an air blast and passes from the gin in a continuous sheet. It is taken automatically to the press, where it is packed by means of hydraulic or steam power into a compact bale.

The seed cotton is usually drawn from the wagon to the gins by suction and automatically divided among the several machines with which each ginnery is provided. From these, the lint cotton is all gathered into one bale, while the seed is carried to an elevator, so that in a very few minutes a wagon load of seed cotton can be ginned, the lint cotton baled and returned to the farmer's wagon, and the seed delivered to him from the elevator. During this process, practically no hand work is necessary. Cotton may be seriously damaged if the gin is run at too high a rate of speed or if the cotton is

damp when ginned. Sea Island cotton is ginned in what is known as the roller gin, as the fiber is seriously damaged by the ordinary type of saw gin.

615. The Cotton Bale. The standard square bale of cotton weighs about 500 pounds gross, with a net weight of 478 pounds of lint. The difference of 22 pounds consists of "bagging and ties," that is, the bagging with which the bale is wrapped and the iron bands by which it is held in shape. The general run of cotton bales averages a little more than 500 pounds in weight. A bale of cotton is a compact mass of lint cotton about 54 inches long, 44 inches wide, and 24 inches thick. Round bales averaging 250 pounds in weight are sometimes made. These are more compact than the square bale and are made with less injury to the fiber, as the sheet of lint is wound directly upon a cylinder as it comes from the gin. Before cotton is shipped any considerable distance, the square bale is compressed to reduce the bulk, the 42 to 46 inches of width being reduced to 20 inches. The other dimensions are not changed. In this form, the cotton of the South is shipped to the markets of the world.

MARKETING AND RETURNS

616. Marketing. Cotton is usually sold to local buyers or to representatives of large consumers of the lint. The sales are usually for cash, and a large part of the crop is sold as soon as it is ginned. It is then stored in warehouses awaiting shipment, is shipped at once to the mills, or, if purchased for export, is forwarded to one of the coast cities. Galveston, New Orleans, and Savannah are among the principal export cities. The grower may, however, store his cotton in a warehouse to be sold at some future time or may return it to his farm, if he has the proper conveniences for storage. The seed is either returned to him from the ginnery or purchased by the ginner, who in turn sells it to an agent of the oil mill.

617. Market Grades. The price of cotton is governed largely by its commercial grade, determined by sample. The grades depend on the length and strength of staple, uniformity, and condition of fiber. Cleanliness and freedom from weather injury often have as much to do with the price as the actual grade. For many years, much confusion existed in cotton marketing, as each of the large markets had its own grades. More recently, the U. S. Department of Agriculture formuulated cotton standards and supplied all the principal markets with uniform sets of samples to illustrate them. These standards have now been generally adopted, and quotations, purchases, and sales are based on them.

618. Prices. The relative prices are based on the market grades, but the price itself is fixed by the supply and demand. The price formerly ranged between 8 and 15 cents a pound, but recently has been much higher. The lowest average monthly price of middling upland cotton at Galveston, Texas, one of the principal markets, from 1917 to 1921 was 11.27 cents, a pound, and the highest average monthly price during the same period was 42.99 cents a pound, in April, 1920. The average price for the entire five years on this market was 27 cents a pound. Prices at the other large markets usually rule about the same as those at Galveston. The average farm price of cottonseed in the United States in 1921 was $22.18 a ton, but in 1918 it reached $66.18 a ton.

619. Exports and Imports. Cotton exports were restricted during the World War. High prices here and the financial condition of many European countries, have kept them down since. The average annual exports of cotton from the United States in the five years from July 1, 1916 to June 30, 1921 were 5,811,000 bales, as compared with over 9,000,000 bales annually from 1909 to 1913. During the 5-year period ending June 30, 1921, the average imports of cotton amounted to 330,000 bales a year. In 1920, 24,634,000 gallons of cottonseed oil were exported.

USES OF COTTON

620. The Uses of the Lint. The lint of cotton is the most important of the world's fibers, furnishing clothing for a very large part of all the people. It is the largest item in our world trade, and the production of cotton goods is the largest of manufacturing enterprises. The lint is first spun into thread or yarn and is then woven into all manner of fabrics. Upland cotton is used in the manufacture of a large variety of cloths, either alone or in mixtures with wool, flax, or silk. Thread is largely made from long staple upland, while Sea Island cotton is used for the finer threads and fabrics. Cotton is used extensively in explosives.

621. Uses of the Seed. Cottonseed was for many years thrown away as worthless or was used only as a fertilizer. During the last forty or fifty years the development of the cottonseed oil industry has furnished a ready market for the seed, and it is now a valuable part of the crop. The whole seed is still used to some extent as a feed or fertilizer, but most of it goes to the oil mills. The products from the seed are numerous, the primary ones being the linters, hulls, and meats. "Linters" is the short lint, or fuzz, which covers the seed and which is not removed in ginning. This fuzz is removed by a special ginning process and used for cotton batting, carpets, and coarse twine. The next process is to remove the hulls, as these would absorb the oil. These hulls have some value as fuel and fertilizer, and are also used for feeding to cattle. About 850 pounds of hulls is obtained from a ton of whole seed. The meats comprise about 1,100 pounds of each ton of seed.

After the hulls are removed, the meats are cooked for about twenty minutes to melt the oil and to drive off a part of the water. The oil is then extracted under pressure, a ton of seed yielding about 300 pounds, or 40 gallons, of crude oil. A large number of different grades of oil are obtained by various processes of refining and filtering, and from these

many products and compounds are made. Cottonseed oil is used for cooking, either alone or in combination with animal fats, as lard and butter substitutes such as cottolene and oleomargarine. Some of the grades of oil are used as substitutes for olive and peanut oils and for medicinal purposes, while others are largely used in the manufacture of soaps. The meats from which the oil has been pressed are ground into meal, known as cottonseed meal.

Cottonseed meal is utilized as a fertilizer and as a feed for live stock. As a fertilizer, it is rich in nitrogen and also contains some potash and phosphoric acid. It is commonly used in the fertilization of all crops throughout the South. As a stock feed, it is most largely fed to cattle and sheep. It contains 37.6 per cent of digestible protein and 9.6 per cent of fat, so that it is one of the most concentrated feeds. Cottonseed meal is largely exported, it being in much favor among dairymen and other feeders of live stock in England and elsewhere.

622. Uses of the Stalks. Little use has yet been made of the stalks of cotton, though cattle will eat the young bolls, leaves, and smaller stems if turned into the field after the crop is picked. The stalks may be cut with a stalk cutter and plowed under or they may be burned. Plowing them under is the better practice, since they are of some value for both vegetable matter and fertilizer. Some successful attempts have been made to produce paper from cotton stalks and from cottonseed hulls, but the industry has not yet been developed on a commercial scale. With the rapid depletion of our supply of wood pulp, it is probable that cotton and cornstalks will soon be put to this use.

DISEASES AND INSECTS

623. Diseases. Of the numerous diseases of cotton which occur in various sections of the South perhaps the most important are cotton wilt and root rot. Cotton wilt is some-

what similar to flax wilt. The fungus enters the young plant through the root hairs, and its mycelium fills the cells of the plant, preventing it from obtaining water. The plants become dwarfed, turn yellow, and usually die. As in flax, certain plants seem to be resistant to the disease. If seed is saved from these, resistant strains may be produced. This disease is confined to the southeastern part of the cotton belt. In Texas, particularly on the heavier lands, root rot is common. This disease attacks the roots of all tap-rooted plants, including cotton, the legumes, and many kinds of fruit trees. The most effective remedies in cotton fields are rotation of crops and deep fall plowing. The disease does not affect corn, the small grains, or grasses.

624. Insect Pests. The most important insects which attack the cotton crop are the boll weevil and the boll-worm, though a host of others do more or less damage. The boll weevil was first reported in extreme southern Texas in 1892, though it had been known in Mexico for many years. Since then it has spread through the cotton belt steadily, the advance northward and eastward being at the rate of from forty to fifty miles a year. It is now spread over the greater part of the cotton-producing area.

The boll weevil is a grayish or reddish-brown insect about one fourth of an inch long which lays its eggs in the squares soon after the blossoms fall. The egg hatches and the rapidly growing larva eats the contents of the young boll. In about ten days, it turns into a pupa and a few days later emerges as a weevil. This insect, when it first appears in a district, is very destructive to the cotton crop, but its ravages decrease as farmers learn better how to control it. The most effective methods are the rotation of crops, frequent cultivation to knock off and bury the infested squares, and the early planting of early varieties, as the insects do not become numerous till late in the season. As the weevil gets its food from within, it is not easily reached by poisons applied

to the surface. It has been shown, however, that arsenical poison, applied in dust form when the dew is on the plant, is very efficacious. The weevil takes drink from the moisture on the leaves. From 250 to 1,000 pounds more seed cotton per acre, it is claimed, can be raised on sprayed than on unsprayed plats.

The bollworm is the larval stage of a moth which lays its eggs on the stems and leaves of cotton and other plants. The worm eats the leaves of the cotton and also buries itself in the half-grown boll, eating the young seeds. The methods recommended for the destruction of the boll weevil are also effective with the bollworm. In addition, poisoning with Paris green and the use of trap crops are recommended. As the moths lay their eggs on the most readily available food plants, many of the worms may be destroyed early in the season by planting occasional rows of corn through the cotton field and cutting and destroying these when the worms become numerous.

FLAX

625. Fiber Flax. The cultivation of this crop has already been discussed (page 225). In the United States, flax is grown almost entirely as a grain crop, and the use of the straw for fiber is incidental. It is largely grown for the production of fiber in some portions of Europe, particularly in Russia. It ranks next to cotton in importance among vegetable fibers, the annual production for the five years from 1907 to 1911 averaging 1,572,000,000 pounds as compared with 10,377,000,000 pounds of lint cotton.

HEMP

626. History. Hemp is a native of western and central Asia. It is one of the oldest of cultivated plants, dating back at least 3,500 years. It is a member of the *Moraceae*, or mulberry, family, to which the mulberry, the osage orange,

and the hop also belong. Hemp, *Cannabis sativa*, is a rank, leafy annual, reaching a height of from 8 to 10 or 12 feet. The staminate and pistillate flowers are produced on separate plants; the pistillate plants are more branched and the fiber from them is of less value than that from the staminate. The production of hemp in the United States is confined mostly to central Kentucky, central Tennessee, New York, and Nebraska.

Figure 148. — A shock of seed hemp. (U. S. D. A.)

627. Culture. Hemp is ordinarily sown in April on land that is suitable for the production of corn. Rich land and the use of nitrogenous fertilizers result in increased yields. The seed is sown broadcast or with the grain drill at the rate of from 4 to 6 pecks to the acre. The growth is rapid and there is little trouble from weeds. Harvesting begins as soon as the first seed ripens, which is usually in about three and one half months from planting. The method of harvesting depends on the vigor of the growth; ordinarily the crop is cut with the mower or binder, but if the growth is unusually rank and heavy, the corn knife is used. The plants are allowed to lie on the ground to ret with the dews and rains and are then shocked or stacked. The processes of separating the fiber are quite similar to those described for the production of flax fiber (Section 292). The principal enemy of hemp is broom rape, a parasitic plant, which is best combated by rotation of crops.

The best quality of fiber is produced when hemp is retted under water, as is the custom in some of the European countries. Dew-retted hemp is dark in color and the fiber produced from it is rather coarse. Most of the hemp grown in the United States is used for the manufacture of ropes and of warp for carpets.

OTHER FIBER PLANTS

Several other fibers enter into the world's commercial use; but, as they are not raised in the United States, mere mention is made of them.

628. Manila fiber is derived from a plant that grows luxuriantly in the Philippine Islands. Its length of fiber makes it especially useful for rope, for which purpose it is principally used.

629. Sisal, so-called from a city of that name in Yucatan, is the whitish fiber of henequin, a plant of the Agave family, and cultivated in Central America and the West Indies. It is used for mats and twine, and is sometimes mixed with manila for rope.

630. Jute is the fiber of the inner bark of a plant grown in India. It is used in the making of twine, bags, burlap, carpet, and even wrapping paper.

LABORATORY AND FIELD EXERCISES

1. Make a map of the United States and place a dot in each state for each thousand acres of cotton produced.

2. Make an effort to secure samples of cotton plants representing the different types of cotton. Compare the fiber as to length and firmness.

3. Wherever possible visit cotton plantations and study methods followed as to cultivation, fertilization and boll weevil control and compare results.

4. If statistics are available, make a careful comparison of the relative production of cotton and of wool in the United States both as to quantity and value.

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CHAPTER XXV

TOBACCO

628. Origin and History. Tobacco is one of the comparatively few important cultivated plants which are natives of the New World. At the time of the discovery of America it was grown by the Indians over a large part of both continents. It was taken to the Old World by the early explorers, and its use soon spread among the people there. For many years tobacco was a common medium of exchange among the settlers in Virginia and some of the other colonies. It was even made legal tender in some of them, and values were commonly reckoned in pounds of tobacco instead of in dollars and cents. Much of the early development of Virginia and Maryland was due to the cultivation of this crop, which was the most profitable one grown by the colonists and the only one which they exported in any quantity. Later, it was carried into Kentucky, Tennessee, and Ohio by the early settlers, and these states have always remained prominent in its cultivation.

629. Botanical Characters. The tobacco plant, *Nicotiana tabacum*, belongs to the natural order *Solanaceae*, in which is included the potato, tomato, and eggplant, and such medicinal and poisonous plants as henbane, nightshade, and Jimson weed, or datura. Tobacco is a broad-leaved annual, growing to a height of from 3 or 4 to 8 feet. The leaves, which are the portion utilized, vary greatly in shape, size, and texture in different varieties and under different soil and climatic conditions. Climate and soil have more influence than variety, as widely differing varieties soon assume much the same characteristics when grown in a given locality for several years. The long white or pink tubular flowers are

borne in panicles at the top of the stem and on the ends of the side branches. The numerous and very small seeds mature in a few weeks after the blossoms appear.

630. Composition. Tobacco is rich in plant food elements, containing about 6.7 per cent of nitrogen, 8.5 per cent of potash, and 9 per cent of phosphoric acid. The upper leaves average 2.5 per cent of nicotine, a poisonous alkaloid which characterizes this plant. Tobacco is, therefore, an exhausting crop, but, in turn, is itself good green manure.

631. Types of Tobacco. Several distinct types of tobacco are grown in the United States. The most important are the cigar-leaf, white Burley, heavy, or export, and bright yellow. The types are distinguished more by their uses than by their botanical characteristics. Filler tobacco is grown principally in Pennsylvania, Ohio, and the South, and wrapper grades in the Connecticut Valley, Pennsylvania, Wisconsin, and Florida. White Burley is a distinct type with light green leaves and cream-colored stems and midribs, which is grown most largely in central Kentucky. Most of this type is used in the manufacture of chewing tobacco. In western Kentucky, western Tennessee, and the adjoining sections of Illinois, Indiana, and Missouri, a type known as heavy, dark, or export, tobacco is grown. This is a dark-colored, thick-leaved type which is mostly exported to Europe. In Virginia and North Carolina, the principal type is the bright yellow, which is manufactured into smoking and chewing tobacco.

632. Importance of the Crop. The tobacco crop of the world averaged 2,513,000,000 pounds annually in the five years from 1919 to 1923. Of this crop, nearly two fifths, or 996,000,000 pounds, was grown in the United States. Complete world data for later years are not available. Among the other countries where tobacco is largely grown are British India, with an annual crop of 450,000,000 pounds; Hungary, with 143,000,000 pounds; and Russia, with 177,000,000

pounds. Cuba's crop averaged 57,450,000 pounds for this period. This was mostly high-priced cigar-leaf tobacco. Other important countries in the production of tobacco are Argentina, Brazil, Germany, Turkey, the Dutch East Indies, and Japan.

The average area devoted to this crop in the United States in the period from 1918 to 1922 was 1,742,000 acres, with an average yield of 790 pounds to the acre. The total production averaged 1,376,322,000 pounds, valued at $365,543,000.

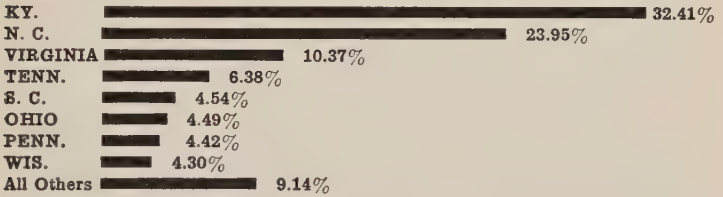

Figure 149.—Percentage of the tobacco crop of the United States produced in each of the leading states, 1918-1922.

Figure 149 shows that nearly one third of the entire tobacco crop of the United States is produced in the state of Kentucky. This state produces more than one seventh of the tobacco crop of the world, and the average value of its annual crop is nearly $106,000,000. In 1919 the crop of this state was 512,000,000 pounds and was valued at more than $195,000,000. North Carolina and Virginia rank next in production, though their combined crop is only slightly more than that of Kentucky. These three states produce about two thirds of the tobacco crop of the entire country. Their acre yield varies from 650 to 900 pounds. In Wisconsin it is about 1,225 pounds, and in Connecticut, 1,480.

633. Soils and Fertilizers. None of our other field crops is so affected in quality and value by soil conditions as is tobacco. The soil should be easily tilled and fertile, containing a large quantity of humus. The different types of tobacco require soils of widely varying character, or what is

perhaps nearer the truth, the different types of soil produce widely different types of tobacco. Clay soils produce heavy tobacco of the shipping, or export, type, while the finest leaf or cigar tobacco is grown on the lighter sandy soils.

While there is a wide variation in the adaptability of soil types to tobacco production, the crop grows better on all soils that are fertile and moist. The growth must be rapid and without check from drought or other causes, else the leaf will be small and of poor texture. The fertilizer which is used depends largely on the soil and the type of tobacco which is grown, but horse manure is quite commonly used when it is available, and commercial fertilizers are also frequently applied. The fertilizer, however, should be well balanced, or the quality of the crop will be injured. An excess of phosphoric acid affects the color of the ash in cigar tobacco, while excessive nitrogen produces a thick, heavy leaf not suited to cigar use. Some of the cheaper forms of potash, as those which contain chlorine, are injurious to the burning quality of cigars. The fertilizers which are most commonly used with good results are cottonseed meal, high-grade sulphate of potash, and acid phosphate. The fertilizer is usually broadcasted or drilled in before the plants are set, the application varying from 200 pounds to a ton to the acre.

634. Preparing the Seed Bed. Unlike most of our other field crops, tobacco is sown first in a plant bed from which the plants are later transplanted to the field. This is on account of the minute nature of the seeds and the slow growth of the young plants, and also because these beds can be protected from late frosts and the seed, therefore, sown much earlier than would otherwise be possible. It is always desirable to use virgin soil for the plant bed, as it contains a large proportion of vegetable matter and is also comparatively free from weed seeds and insects. The common practice in many sections where such land is available is to clear off a small patch in an open wood, the surrounding

timber furnishing protection from cold and winds. If new land cannot be had, then newly broken sod is commonly used. Cultivated land should be used only when no other is available; but, if it must be resorted to, it should be well fertilized the previous fall with barnyard manure or tobacco stems and the soluble elements allowed to leach into the soil during the winter. The manure or stems should then be raked off in the spring and the bed treated as a new one.

During the winter, the bed should be burned over to make the soil friable and to kill all weed seeds and insects. These purposes are usually accomplished by piling brush and logs over the bed and burning them. A low, steady fire is more effective than a high, quick one. The soil should be thoroughly heated to a depth of several inches.

The size of the bed is naturally governed by the acreage to be planted. Enough plants can be produced on from 75 to 100 square feet to plant an acre, but it is safer to have from 150 to 200 square feet of bed for each acre to be planted. This space gives much more opportunity for the selection of the best plants. The most convenient shape for the plant bed is one about 3 feet wide and as long as may be necessary, for this width makes it easy to reach to any portion of it from one side or the other.

635. Sowing the Seed. As the seed is very small, it is usually mixed with dry wood ashes or some other fine material to give bulk and insure even distribution. A teaspoonful of seed will sow from 200 to 300 square feet of bed. Before sowing, the light and immature seeds should be blown out with a tobacco-seed grader, as the larger, heavier seeds give much better plants. The date of seeding depends largely on the date of the latest spring frost. In order to have the plants ready for setting in the fields as soon after this date as possible, the seed should be sown about two months previous. This necessity requires March seeding in Kentucky, Tennessee, and Virginia, while the seed is sown in

April in the states farther north. The seed should be distributed over the bed as evenly as possible and covered very lightly. The usual method of covering is to sprinkle the bed thoroughly with water, though a board is sometimes used to

Figure 150.—The kind of tobacco crop that is produced when good plants from selected seed are planted on suitable land and given good care.

press the seed into the soil or it is covered by brushing the surface of the bed lightly with a whisk broom.

On account of this early seeding, some protection from cold is necessary. This is usually provided by driving stakes into the ground along the edges of the bed and building a tight enclosure of boards about 1 foot high. This is then covered with glass or plant muslin, the cloth being more com-

monly used, as it gives better ventilation, is cheaper, and the plants under it are less subject to disease. It is necessary to water frequently, at least as often as three times a week, for the plants should never be allowed to become stunted from drought or any other cause.

636. Preparing the Field. As tobacco is a crop which gives large returns when properly grown, it well repays much care and attention in fitting the field and in cultivating the crop. Spring plowing is most commonly practiced on new land and on fields where there is a blue grass or clover sod, or where cover crops are grown. It is preferable to have a cover crop on the land over winter to prevent washing and leaching of the soil. It is then disked and harrowed at intervals of a week or ten days till the plants are set in the field. This frequent working puts the surface soil in fine condition, helps to hold the moisture, and kills the weeds. The fertilizer is distributed just before the rows are marked for planting.

637. Setting the Plants. When the danger of frost is past, the plants are removed from the bed and set in the field. Early setting is advisable, as a larger percentage of the plants will survive and the plants will mature when conditions for curing are best. In order to retain all the small, fibrous roots and to prevent injury as much as possible in removing the plants, the bed is thoroughly sprinkled before the plants are pulled. They are usually taken up in the morning and packed tightly in baskets or boxes for carrying to the field. If they are not set at once, it is best to keep them in a cool, shady place till wanted. Small or diseased plants should be discarded. If the weather is cloudy, the plants may be set at any time during the day; if it is clear, setting in the afternoon and evening is safest. The plants are set either by hand or with the transplanting machine, the machine being used generally where large acreages are grown. If the soil is dry, water is applied at the time of setting, but it is not necessary to do so when there is plenty of moisture.

A few days later, all dead plants should be replaced with fresh ones from the plant bed. The distance between the plants differs with the variety and the soil, though the usual distance between the rows is from 3 to 4 feet, with the plants from 18 to 24 inches apart in the row. With a planter, 3 acres can be set in a day, three men and a team being required in its operation.

638. Cultivation. As soon as the plants start into growth after transplanting, the ground should be stirred. The earlier cultivations are usually with the shovel plow, to loosen the soil to a depth of several inches and admit air and heat. Later, surface cultivation is given, to keep down weeds and maintain a dust mulch. The soil should be worked toward the plants rather than away from them, using great care not to injure the roots. Every effort should be made to induce steady, rapid growth. It is best to continue the cultivation at intervals of a few days until the plants shade the ground quite completely; after that time, the leaves are likely to be broken or injured by it. Later workings are usually given with a one-horse spring-tooth cultivator.

Shade-grown tobacco generally grows taller and matures thinner and more pliable leaves preferred for wrappers. The shade is produced by nailing lath or extending cloth over a framework. The laths are arranged to give half shade.

639. Topping. When from ten to eighteen leaves have been produced, the top of the plant is broken out to prevent the production of seed and to increase the size and substance of the leaves. Considerable judgment is required in this work, for on it depends in large measure the uniformity and yield of the crop. Slow-growing plants or those on poor soil are usually allowed to develop fewer leaves than those on rich soil or which are making rapid growth. Soon after the top is removed, suckers will be produced from the axils of the leaves. These should be removed when they reach a length of about 3 inches. It is necessary to go over the field

several times to remove these suckers, since they continue to appear as long as the plant is growing. If they are allowed to develop, they reduce the value of the leaves on the main stalk by depriving them of much plant food.

640. Harvesting the Crop. Two methods of harvesting

Figure 151.—Harvesting tobacco. The stalks are strung on laths and loaded on the frame on the wagon, to be hauled to the barn for curing.

tobacco are in common use. Where cigar-leaf tobacco is grown, the leaves are commonly "primed"; that is, the lower leaves, which always mature first, are first removed, and the others taken off as they ripen. Other grades of tobacco are commonly harvested by cutting the entire plant with a corn knife or a special knife devised for the purpose. The proper stage of ripeness is indicated by a slight yellowing of the leaves and by several other tests known to the grower, such as the "feel" of the leaves and the brittleness of the veins. The plants are usually ready to harvest about a month after topping.

Where the leaves are cut singly, they are strung on laths, which pierce them near the base, thirty to forty leaves being put on a lath. If the entire plant is cut, from four to six are put on a lath, according to the size of the plant. A

removable metal spear is placed on the end of the lath and run through the base of the stalk. The leaves are allowed to wilt for a few hours, and are then hauled to the barn for curing. In hot, sunshiny weather the wilting is best accomplished by hanging the laths close together on a temporary scaffolding in the field, as the leaves are likely to sunburn if

Figure 152.—A tobacco curing barn with horizontal ventilators. The method of hanging the leaves in the barn is shown.

left fully exposed to the sun's rays. Leaves which are "yellowed" or wilted on the scaffold are less likely to burn in curing. Care should be taken throughout the harvesting process to avoid injury by bruising.

641. Curing. The curing process depends largely on the use which is to be made of the crop. The object is to remove the moisture in the leaves and stems in such a way as to produce an even texture and coloring in the leaves. For this purpose, the tobacco is hung in the curing barn as soon as it has wilted. Scaffolding is provided so that the laths may be hung in tiers, giving plenty of room between the plants for ventilation. The plants should be shaken when

hung in the barn, to prevent the leaves from sticking together. Good ventilation at the sides and top must be provided.

Ordinarily, the tobacco is air-cured, though in damp seasons some artificial heat may be necessary. In dry weather, the ventilators are left open day and night. On damp days, they should ordinarily be open during the day, though they may be closed at night. If the air is very damp, the ventilators may be kept closed for as long as forty-eight hours, or until the saturation point is indicated by the "sweating" of the tobacco. They must then be opened and charcoal fires built to create a circulation of air, else "houseburn" and discoloration of the leaves may result. It is then said to be fire-cured. When cured in close quarters with higher degrees of heat, it is said to be flue-cured. Two months are ordinarily required for curing, though the process may be completed in less time if artificial heat is used. Rapid curing, however, is likely to produce poor color.

642. Stripping and Grading. Moist days during the winter are usually selected for stripping, or removing the leaves from the stalks. In some localities, the tobacco is removed to a damp cellar before stripping. When the leaves contain sufficient moisture, they may be handled without cracking or breaking. Much depends on having the leaves in proper "case"; that is, in having them contain just enough moisture to handle readily. If too dry or "going out of case," they will continue to dry out when bulked and will become brittle; while, if they are too moist or in "too high case," they will become very dark when in bulk.

The leaves are sorted into from three to five grades as they are stripped, the number of grades depending on the type of tobacco and the use which is to be made of it. These grades have different names in the different types, and vary materially in their market value. The central leaves on the stalks usually go in the best grade. After the leaves are graded, they are tied in small bundles and these into larger

bundles, the form and size of the package depending somewhat on the kind of tobacco. Tobacco which is packed in the winter will sweat in May, and must be hung out to dry or it will rot. It may then be bulked and will keep indefinitely, as will that which is put down in "summer order"; that is, allowed to hang in the curing shed over winter and then stripped and packed the following summer.

643. Marketing. The method of marketing depends on the distance which the tobacco must be shipped. If factories or warehouses are close by, it is marketed loose. If it must be shipped a considerable distance, it is packed tightly into hogsheads or large casks. The manner of packing depends largely on the market. Only one grade should be put in a package, and care should be exercised in packing in order to obtain the best price. There are usually warehouses or factories close to the tobacco fields, so that the farmer need not pack his crop.

644. Returns. The price of tobacco varies widely from year to year, according to the supply and other causes. There are also wide differences in price among the different grades. The average price per pound for the ten years from 1913 to 1922 was 22.9 cents in Kentucky, where smoking and heavy export tobaccos are largely grown; in North Carolina, where chewing and the better grades of smoking tobacco are grown, it was 34.1 cents; in Connecticut, where the crop is entirely used for the manufacture of cigars, the average price per pound was 38.7 cents; and in Florida, where the best grade of cigar wrappers is produced, the average return to the grower was 47.1 cents.

As the acre yield varies from 600 to 1,500 pounds or even more, it can readily be seen that the value of an acre of tobacco is high, and justly so, as the expense of growing the crop is heavy. The average value per acre in Kentucky for the five years from 1918 to 1922 was $196.49; Virginia, $185.41; North Carolina, $215.93; Connecticut, $567.25; and Florida,

$468.07. The Connecticut and Florida tobacco is largely grown under the shade of muslin screens and the cost of production is high, so that the net returns, while greater than in the other states, are not so large as might at first appear.

645. Rotation. A Virginia rotation for dark tobacco is: First year, tobacco; second year, wheat; third and fourth years, mixed grasses and clover; fifth year, corn; sixth year, cowpeas. A Pennsylvania rotation is: First year, wheat; second year, grass; third year, tobacco. The rotation may be extended a year by growing corn after wheat. In Kentucky tobacco is sometimes grown for two years in succession after a crop of blue grass. In Wisconsin it is advocated that on low and prairie soils, well-supplied with humus and nitrogen, and even on sandy and clay loams a rotation need not be employed till depreciation occurs.

646. Insects and Diseases. Tobacco is not subject to injury from many insect pests or diseases. The most frequent pest is the horn worm, or tobacco worm, which feeds on the leaves. This may be killed by applying from ½ to 1 pound of dry Paris green to the acre, mixing the poison with about twenty times its bulk of flour and applying it to the plants with a bellows. If too much poison is used, it will burn the leaves. The smaller worms are killed by the Paris green, but it does not affect the larger ones. These must be removed by hand picking. Few diseases attack the plant in the field. Damping-off, or bed rot, and other fungous diseases sometimes occur in the plant bed, but these are ordinarily controlled by burning the bed before seeding, sowing only the best seed, and giving proper attention to ventilation and watering.

647. Selection of Seed. A few of the choicest plants may be allowed to produce seed. As half a dozen will produce enough seed for several acres, there is plenty of opportunity for the selection of only the very best plants. These ought to be uniform and typical of the variety or type which is

being grown. The market value of the crop can be materially increased by care in the selection of the seed plants. As soon as the flower stalks appear, but before any flowers open, the head should be covered with a 12-pound manila paper bag, for experiments have shown that self-fertilized seed produces much more uniform plants than that which is open-fertilized. After a few days, the bag is taken off temporarily and all superfluous leaves and blossoms removed, leaving from forty to eighty seed pods. It is then put back, and taken off at intervals of a few days to remove new flower buds which may have formed. After three or four weeks, the bag is taken off permanently, care still being given to remove all flower buds which develop afterwards. When the pods turn brown, the stem is cut off and hung in a dry, airy place for curing. The seed should be stored in a dry place and safe from the attacks of mice and insects, for on it depends largely the value of the succeeding crop.

LABORATORY AND FIELD EXERCISES

1. Examine the different kinds of leaves used for different purposes. What are the characteristics of each?

2. Grow a few tobacco plants with different fertilizers and without fertilizer, and note results. Also grow some plants under shade, and note what differences may appear.

3. Visit fields and barns, if possible, and observe methods of planting, growing, and curing.

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PART V—CONCLUDING CHAPTERS

CHAPTER XXVI

ROTATION OF CROPS

648. Definition. A rotation of crops, according to the Cyclopedia of American Agriculture, is "a recurring succession of plants covering a regular period of years and maintained on alternating fields on the farm." Crop rotation can best be explained, perhaps, by giving an example of it which is common in many sections. A cultivated crop, as corn or potatoes, is grown on one part of the farm the first year; a grain crop, as wheat, oats, or barley, on another; and a grass crop, as timothy, clover, or brome grass, on a third part. The following year the grain will occupy the land where the cultivated crop was grown; the grass crop, which was sown with the grain the first year, will occupy that land; while the land in grass the first year will be broken and planted to a cultivated crop. This regular sequence of cultivated crops, grain crops, and grass crops, is called a rotation of crops. Unless there is some definite plan and reason for such a sequence, it cannot properly be called a rotation. For instance, the alternating of oats or barley or flax with wheat in a spring-wheat region can hardly be called a rotation, for it does not conform to the principles on which crop rotation is based.

649. Origin of Crop Rotation. The system of farming which was originally followed was to grow a crop on a piece of land continuously until the yields decreased below the point where production was profitable. Then the land was allowed to "rest"; that is, it reverted to a state of nature, growing up to weeds, brush, or trees, while a new field was

cleared for the farm operations. If the old piece was again cleared after a few years, its original fertility would be found to be largely restored, for the plants which grew on it during the interval drew the plant food from the soil as it became available and returned it with each recurring season.

After a time, the practice became common of resting the land for but a single season, allowing it to grow up to weeds and then plowing them under. This was less expensive and laborious than clearing new land, while its effect on crop yields was nearly as good. As agriculture advanced, the land was cultivated during this resting period to prevent the growth of weeds and what was known as the "summer fallow" was developed. Still later, a cultivated crop was substituted for the summer fallow, for land was constantly becoming more valuable and it was not profitable to allow it to lie idle every alternate year. Crop rotation was thus eventually developed. This same process of evolution from continuous cropping to a systematic rotation of crops is repeated in more or less detail in practically every newly settled country. It is now taking place in a large part of our western territory, though here the lack of rainfall may interfere in some degree with the adoption of logical rotation systems.

HOW ROTATIONS HELP

650. Advantages of a Rotation. A rotation of crops improves the physical condition of the soil, helps to conserve moisture and vegetable matter in the soil, lessens the damage from insects and plant diseases, aids in the control of weeds, increases crop yields, distributes the labor of crop production, and helps to systematize farm operations.

651. Rotation Improves the Physical Condition of the Soil. The roots of all plants do not penetrate the soil to the same depth. Deep-rooting plants like clover and alfalfa enter the lower layers of the soil. When their roots decay they open channels for the passage of air and moisture and

make it easier for the crops which follow to draw on the stores of plant food in the subsoil. Constant cultivation and the growing of cultivated crops tend to decrease the supply of vegetable matter in the soil, because favorable conditions for its decomposition are provided. Grain crops add little in the way of vegetable matter unless the straw is returned in manure, as the roots and stubble are not bulky. The grasses, however, grow for two or more years and accumulate a large quantity of fibrous material, which tends to restore the supply of vegetable matter. If a portion of this matter is in the lower soil layers, as in the case of deep-rooting plants, it further improves the physical condition. The varying cultivation which is given to different crops is also of benefit, for the soil is stirred to different depths and aërated.

652. Rotations Conserve Moisture. Practically all systems of rotation include, at some time during their course, one or more cultivated crops. Cultivation, by maintaining a surface mulch and lessening evaporation, helps to hold the moisture in the soil. Moisture passes very readily from stubble land, or from any bare, untilled field, but the tillage given a cultivated crop conserves moisture for the next crop.

653. Rotations Conserve Vegetable Matter. Constant cultivation and the removal of crops rapidly reduce the vegetable matter in the soil. A rational system of rotation includes the keeping of more or less live stock to turn the bulkier and less valuable products of the farm into more concentrated and more readily salable products. With proper care given to the manure, a large part of this vegetable matter may be returned to the soil. While grain crops and cultivated crops are exhaustive of vegetable matter, grass crops, because they have extensive root systems, materially increase the vegetable matter in the soil.

654. Rotations Lessen Damage from Insects and Diseases. Most of the plant diseases and injurious insects are decidedly limited in the number of plants on which they can

live. Many of them are destructive to only one of the crops commonly grown. They are not generally capable of movement for any considerable distance during a season, but increase very rapidly from year to year if a single crop is grown repeatedly on the same land. The change of crops from one field to another helps to keep these pests under

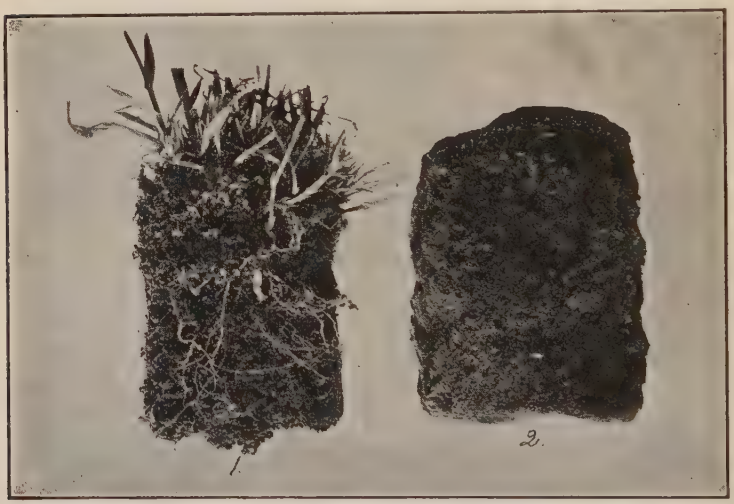

Figure 153.—Samples of soil from (1) a grass plot, and (2) from one which has been in corn continuously for a number of years. Note the absence of vegetable matter in the sample from the corn field.

control. As most plant diseases are unable to maintain themselves for more than three or four years in the soil without their particular host crop on which to grow, the crop may be returned to the land at the end of such a period with little fear of injury. The same statement is true to a lesser extent of insects. Some of them will go from field to field, but the greater part of them will die for lack of suitable food if crops on which they do not feed are introduced.

655. Rotations Aid in Keeping Down Weeds. Some weeds grow best in certain crops or under certain conditions;

others thrive under totally different conditions. The small grains offer particularly favorable conditions for the growth of many weeds. The spring grains are sown before many of the weed seeds germinate, and ordinarily no effort is made to control weeds which come up in them, so that they are allowed to grow unmolested till harvest. Even less opportunity is afforded to combat weeds in fall grain, except that the grain begins growth earlier in the spring than many of the weeds and is harvested earlier than some of them mature their seed. By harvest, most of the annual weeds have ripened their seeds and have thus had every chance to increase. Meadows and pastures offer less favorable conditions for annual weeds, as the crops and weeds are cut or eaten off by stock, and when a good sod is established it affords little opportunity for weeds to get a start. Biennial and perennial weeds, however, often thrive in meadows and pastures, if the field is left undisturbed for several years and there is no chance to destroy them by stirring the soil. Cultivated crops offer opportunities for the destruction of weeds of all classes. In other words, weeds increase rapidly in grain crops, some classes decrease while others may increase in meadows and pastures, and all classes decrease in fields on which cultivated crops are grown and given proper attention.

656. Rotations Insure Returns. A rotation of crops, with the diversification which it necessarily implies, insures some return for the season's labor. Seasonal conditions may be such as to cause the total failure of one crop, but it is very seldom, at least east of the 100th meridian, that all the crops on the farm fail to yield a profitable return. Conditions that are unfavorable to oats or wheat may be quite suitable for corn or hay, so that if one has several crops he is much surer of some return for his labor than if he depends entirely on one. The old caution, "Do not put all your eggs in one basket," applies as well to crops as to anything else. Plant diseases or insect pests may destroy one crop, but they are

seldom destructive to all crops in any one year. The diversification of crops has been the best means of preventing financial disaster in the sections of the South which have been invaded by the cotton boll weevil, just as it has been under similar circumstances in other sections.

657. Rotations Increase Crop Yields. One crop helps to prepare the soil for the one which follows. Clover opens the subsoil and adds nitrogen and vegetable matter for the corn or potato crop which comes after it. A cultivated crop preceding one of small grain puts the soil in the best physical condition, conserves moisture, and cleans the land of weeds. If the crops which are produced are largely fed on the farm and the manure returned to the land, crop yields will be further increased, because each crop, except perhaps the small grains, increases the available supply of plant food. The grasses and clovers add vegetable matter to the soil, while cultivation unlocks a part of the store of plant food and makes it available for the use of plants.

658. Rotations Distribute Farm Labor. Growing a single crop or a single class of crops limits the seasons at which farm work can be done. The growing of small grains requires a rush of work during a few weeks while the land is being prepared and the crops seeded, and again during harvest, with little employment during the remainder of the year. Cultivated crops in general are planted later than the small grains and most of the work of cultivation is done before grain harvest, while they are not ready to gather until the grain crops are safely housed. Hay crops require little labor except at the haying season, which usually comes when other crops do not require much attention, except that it may sometimes conflict with the harvest of small grains, or the cultivation of intertilled crops. The harvest of such crops as alfalfa, which yield several cuttings during the season, may conflict with the handling of other crops, but such conflicts can hardly be avoided. A diversity of crops usually

encourages the keeping of more live stock than single-crop farming, and live stock usually requires more attention during the season when the crops require least care, thus distributing labor throughout the year. The system of farming which provides employment for the farm labor throughout the greater part of the year is the one which is most likely to prove stable and profitable, other things being equal.

659. Rotations Systematize Farm Operations. A rotation implies a definite system of operations. The following of a rotation allows the farmer to plan his work more definitely during the season and to figure more definitely on crop yields and income. Rotations tend to the division of the farm into regular units of uniform size, and decrease rather than increase the number of fields on most farms. By effecting a more uniform distribution of farm labor throughout the season, a smaller and much more permanent force is required, which in itself tends to place the work of the farm on a stable and systematic basis.

660. Rotations Do Not Conserve Fertility. Many persons hold that rotations conserve soil fertility. While crop yields will decrease much more slowly where several crops are grown in a rotation than where any one is grown continuously, crop rotation is just as certain to exhaust the supply of available fertility eventually, if no fertilizers are used, as is a single cropping system. The various crop plants all use the same elements of plant food, though some draw more heavily on one element and some on another. The three which are most largely used and most likely to become depleted are nitrogen, phosphorus, and potassium. The legumes take the nitrogen from the air and store it in the soil in a form available for other plants, so that if a leguminous crop is grown as often as once in three years there is little danger of the exhaustion of this element, but nature's supply of potassium and phosphorus must eventually be supplemented.

Live-stock farming aids in conserving these elements, for live-stock products remove much less of them than grains, hay, and cotton. If the manure is properly handled and returned to the land, the exhaustion of the soil will be very slow, but it will be constantly taking place. The products which are sold will remove some of the potassium and phos-

Figure 154.—Good plowing is essential to the production of good crops.

phorus, while there will also be a considerable loss by leaching from the soil and from the manure. Some phosphorus and potassium should occasionally be added from outside sources in the form of purchased feeds or of fertilizers in order to maintain or to increase the fertility of the soil.

WHAT A ROTATION SHOULD CONTAIN

661. Classes of Crops in a Rotation. So far as their arrangement in a rotation is concerned, field crops may be divided into grass, grain, and intertilled, or "fallow," crops. Grass crops include all the plants which are grown in meadows and pastures, such as the perennial forage grasses, clovers

and alfalfa. These remain on the land for two or more years and increase the supply of vegetable matter by the mass of stubble and roots which they produce. All annual crops not intertilled will be designated in this discussion as grain crops. They are sown too thickly to allow intertillage, and occupy the land but a few months. They exhaust the supply of humus and plant food elements, and are also exhaustive of soil moisture. This class of crops includes wheat, oats, barley, rye, flax, buckwheat, millet, and all annual forage crops similarly produced. Intertilled crops are planted in rows wide enough apart to be tilled during a large part of the growing season. They are also exhaustive of soil fertility, and while the cultivation tends to "burn out" or hasten the decomposition of vegetable matter, it aids in the changing of plant food from insoluble to soluble forms and also conserves moisture. Intertilled crops include corn, cotton, potatoes, sugar beets, tobacco, and many others of less importance. The annual leguminous forage crops may be cultivated like corn or sown broadcast. Their effect on the soil is very similar to that of other crops, except for their ability to add nitrogen.

662. The Essentials of a Good Rotation. The essentials of a good rotation are:

An intertilled crop.
A crop for cash returns,
A crop for feeding to live stock, and
A crop to increase the supply of vegetable matter and nitrogen.

Two or more of these essentials may be embraced in a single crop. Thus clover supplies a crop for live-stock feeding, and is one which increases the supply of humus and nitrogen. Corn is a cultivated crop, and may be either a cash crop or one for feeding to live stock.

663. An Intertilled Crop. As already stated, weeds increase when grain crops are grown, and the methods of

Figure 155.—A corn-wheat-clover rotation (on the left) vs. continuous corn growing (on the right). Note the difference in growth of the crop as shown in the upper pictures, also in soil texture and content of vegetable matter as indicated in the lower views. A good rotation pays.

destroying them are limited. Some classes of weeds increase in meadows and pastures. An intertilled crop is needed at intervals to subdue weeds and to keep them from overrunning the land. Tillage aids in retaining the soil moisture and in liberating supplies of plant food. Stirring the soil allows the air to penetrate to the roots of the plants and enables them to grow better than in hard, cloddy ground. The aëration of the soil also improves its texture and provides more favorable conditions for the growth and work of some of the beneficial bacteria.

664. A Crop for Cash Returns. It is essential, if the work of the farm is to be made profitable, that at least one crop be grown for cash returns. It need not necessarily be one which is sold in its natural state, for it may be converted on the farm into animal products and then marketed. On many farms, however, some crop is grown for direct sales for cash or its equivalent. If no cash crop is grown, there is no opportunity to increase the available funds for necessary improvements or for the purchase of food and clothing and other necessities of life which cannot be produced on the farm. It might be possible to follow a rotation of crops which would rapidly increase the available supply of plant food by growing only such crops as clover, rye, and cowpeas and continually plowing them under as green manure crops, but this practice would yield no cash returns and could be followed only where there was some source of income from outside the farm. In general, the growing of a cash crop is a necessity. Cotton, wheat, potatoes, tobacco, flax, barley, and sugar beets are important crops which are grown for direct sales. Hay and corn frequently become cash crops indirectly by marketing them through live stock.

665. A Crop for Feeding to Live Stock. At least one crop should be included in the rotation which can be used for feeding to live stock. The necessary work stock should be fed, as far as possible, on products grown on the farm,

for it is usually cheaper to grow their feed than to purchase it. It is generally profitable to keep some cattle, hogs, and sheep, or at least one of these classes of animals, to convert much that is grown on the farm into more readily marketable or more valuable products, and at the same time to return to the land in the manure a large part of the fertility which is removed by the crops. Live-stock farming will postpone soil exhaustion much longer than grain farming if no fertility is brought to the farm from outside sources. Among the crops which may be grown for live-stock feeding are corn, grass, clover, alfalfa, oats, and barley.

666. A Crop to Supply Vegetable Matter and Nitrogen. It is necessary to conserve the supply of vegetable matter in the soil, in order to maintain profitable crop yields. The exhaustion of the vegetable matter makes the soil "hard to work"; it becomes stiff and lifeless, bakes and clods badly, and dries out very quickly. Vegetable matter improves the physical condition of the land and increases its moisture-holding capacity. The acids formed through the decay of this organic matter also help to unlock the unavailable supply of some of the elements of plant food by changing the nature of the compounds and by acting as a stronger solvent than water. Nitrogen, the most expensive of the three elements of plant food usually purchased in the form of commercial fertilizers, can be added to the soil very cheaply through the medium of leguminous crops. The grasses increase the supply of vegetable matter; the legumes increase the supply of both vegetable matter and nitrogen. Vegetable matter is also added to the soil in corn and cotton stalks, straw, stubble, and manure. The more important crops to supply vegetable matter are clover, alfalfa, the perennial grasses, cowpeas, soy beans, field peas, and green manure crops such as rye, vetch, and rape.

667. What Crops to Grow. The crops which are included in the rotation depend entirely on the kind of farming which is

followed, the crops which succeed best in the locality, and the individual preferences of the farmer. All the farm need not necessarily be included in a single rotation. It may be advisable to have a primary rotation for the greater part of the land, and a secondary one for a smaller portion of it which is different in texture or fertility, or to supply crops for a special purpose. Thus the greater portion of the farm may be devoted to the production of wheat and potatoes, with clover to complete the rotation. A rotation which includes these three crops embraces two cash crops, wheat and potatoes; an intertilled crop, potatoes; a crop for live stock, clover, with the wheat straw as roughage and bedding; and a crop to add humus and nitrogen, clover. Such a system would not supply enough feed other than clover hay for any large number of live stock. If the section is adapted to the production of corn, either for grain or for forage, that crop might be added to the rotation, or a secondary rotation might be devised on another part of the farm, in which corn, oats, and clover may be grown. Here all three crops would be suitable for feeding to live stock; all might be considered as cash crops, as they would be marketed through the live-stock products; corn would supply the intertilled crop, and clover, the vegetable matter.

668. When to Apply Manure. Many of the best systems of crop rotation, as already stated, include the feeding on the farm of a large proportion of the crops which are produced, and the return of the fertility in the form of manure. As a general thing, this manure may be applied to best advantage to the grass crop or to the cultivated crops. Whenever it is practicable, it should be hauled to the field during the winter as it is made, as the loss from leaching there is less than if it is left in the barnyard. If the manure can be stored under cover where it will not leach away, it may be left to decay.

Well-rotted manure is less bulky and likely to contain dangerous weed seeds than fresh manure; but under most

other conditions it should be applied to the field as soon as possible, because there is less waste than in rotted manure, and the active rotting of fresh manure in the soil warms it and aids bacterial and chemical action. Manure may be applied to meadows at any time except during a few weeks before haying, while it may be spread on pastures through-

Figure 156.—The manure spreader distributes the manure evenly over the soil so that it can be plowed under without trouble and placed where it will be most easily reached by crops. The easiest way to handle manure is to load it directly into the spreader from the stable.

out the year, though it is usually best to apply it to them during the winter. In the South, where a perennial grass crop is not often grown, manure is usually put on the land before planting the principal crop, which is generally cotton or corn.

669. Length of the Rotation. The length of the rotation depends on the crops which it includes and the system of farming which is followed. It may be a 2-year, 3-year, or 4-year rotation, or it may be planned for a much longer period. The most common rotations are 3-year, 4-year, and 5-year ones.

SOME SUGGESTIVE ROTATIONS

670. Rotations for Various Sections. It is not possible to outline a single rotation or even several rotations which will fit all cases, for that matter must be left to the needs,

facilities, and inclinations of the individual farmer. The rotations that are suggested here are in more or less common use, and include the principal crops of the sections specified. They may be varied in almost innumerable ways.

671. In New England, special crops are grown or special lines of farming are followed in the different sections, and the rotations depend entirely on the particular system in vogue in the locality. Where potatoes are the main crop, the rotation is often as follows: 1, potatoes; 2, oats, with clover seeded in the oats; 3, clover.[1] The clover may be left for two years, or the potatoes may be grown for two years in succession. In the dairy sections, fodder corn is one of the principal crops. Here the rotation may be: 1, corn, cut for silage, followed by rye; 2, rye, plowed under for green manure, followed by corn and rye as before; 3, rye, with clover seeded in it; 4, clover. In the tobacco district, tobacco may take the place of the second crop of corn.

672. In the North Atlantic states, dairying is generally important. Here a common rotation is: 1, corn; 2, wheat, seeded to clover and grass; 3, meadow; 4, pasture. The pasture may be left for one or more years. A little farther south, where cowpeas and crimson clover can be grown, the rotation may be: 1, corn; 2, wheat, followed by cowpeas; 3, cowpeas, cut early for hay, followed by grass; 4, meadow; 5, pasture. The simple 3-year rotation of corn, wheat, clover, or corn, oats, clover, may also be followed.

673. In the Southeastern states, rotations are less common, for the land is kept quite constantly in cotton. On account of the possibility of growing several crops during the year, many different combinations of crops may be made. One which includes the two most important crops, corn and cotton, and also embraces all the features of a good rotation,

[1] In this discussion of rotations, the figures refer to the year in the rotation. Thus, in the one just given, a crop of potatoes is grown on a given piece of land the first year; the second year it is sown to oats, with clover seeded in the oats; while the third year it is a clover meadow or pasture. If potatoes are grown for two years, it would be: 1, potatoes; 2, potatoes; 3, oats; 4, clover.

is: 1, cotton, followed by rye or bur clover; 2, corn, with cowpeas sown in the corn, followed by winter oats or winter barley; 3, winter grain followed by cowpeas cut for hay, the land then being sown to rye or some other winter cover crop. A more simple rotation, but one which lacks an essential feature of all cropping systems for the South, the winter cover crop, is: 1, corn and cowpeas; 2, winter grain, followed by cowpeas; 3, cotton; 4, cotton or corn. A simple alternation may be followed in some sections, such as cotton and bur clover or winter wheat and cowpeas. With the addition of phosphorus and potassium, this is very successful.

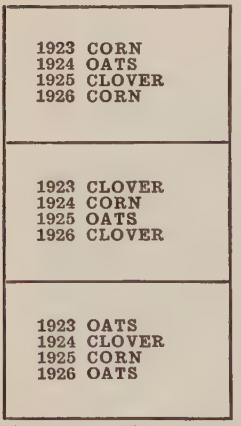

Figure 157.—The arrangement of the fields and crops in a 3-year rotation of corn, oats, and clover.

674. Rotations in the Central States. In the Central states, in what is commonly known as the corn belt, the one crop on which all systems of farming are based is corn. The three principal crops are corn, wheat, and grass or corn, oats, and grass, and they are arranged in the rotation in the order named. Two crops of corn may be grown in succession or the land may be left in grass for one, two, or more years, either as meadow or pasture. A very common form of this rotation is the 5-year one, as follows: 1, corn; 2, corn; 3, oats (or wheat); 4, meadow; 5, pasture. It is possible in the southern part of the corn belt to grow a crop after grain, if the land is not seeded to grass. A rotation embracing this feature might be devised like this: 1, corn; 2, oats, followed by cowpeas or soy beans; 3, wheat; 4, meadow; 5, pasture.

In Minnesota, Wisconsin, and the Dakotas, some of the rotations used in New York and New England may be profitably followed. In the Dakotas and farther west, rotations

are not commonly practiced, only small grain crops being extensively grown. A system of farming based on a single class of crops can hardly be called a rotation. The land is usually sown to flax when it is first broken; wheat is then grown for a period of years, when one or two crops of oats or barley may be introduced, to be followed again by wheat. Under this system, weeds increase rapidly, and it is often necessary to resort to the bare fallow or, preferably, to introduce a cultivated crop to control them. The crops which are commonly introduced are corn and potatoes, and both are usually grown with success.

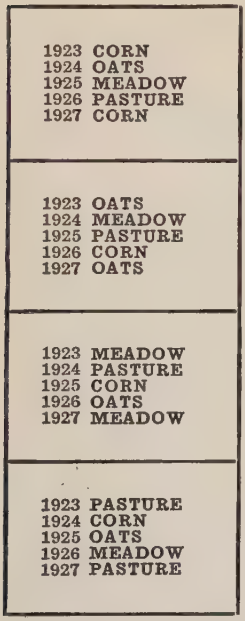

Figure 158.—An expansion of the rotation in Figure 157 into a four-year rotation. Timothy is sown with the clover and is cut for hay the first year after seeding; the second year, it is pastured.

675. Rotations in the Far West. In the Great Plains, Rocky Mountain, and Pacific states the systems of farming are yet too new for any general series of rotations to have been adopted. One which may be followed in the irrigated districts embraces three or four successive crops of alfalfa, followed by one or two crops of potatoes or sugar beets and perhaps one or more of barley, wheat, or oats, when the land is again seeded to alfalfa. In California, on the dry lands where grain is grown, a more or less definite sequence of wheat, barley, and oats is sometimes followed, but rotations which embrace all the desirable features are little known.

LABORATORY AND FIELD EXERCISES

1. Draw a plan of the home farm or of some farm in the neighborhood and show the crops which are now grown on it. If a definite rotation is now followed, tell whether it is a good one. If it is not,

show how it may be improved to more nearly meet the four essentials of a good rotation. If no rotation is followed, plan one which is suitable for the type of farming which is followed.

2. Plan a 3-year rotation, using the more important crops of your community and taking care that the four essentials are included. In the same way, plan 4-year and 5-year rotations.

3. Plan a rotation which will be suitable for a dairy farm in your section; for a hog and beef-cattle farm; for the production of the leading cash crop.

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CHAPTER XXVII

WEEDS

676. Definition. A weed is any plant which is growing where it is not wanted; that is, a plant out of place. A stalk of corn in an oat field is just as much a weed as is a thistle, though it may do less damage and in its place be a very useful plant. A plant may thus be a weed under some conditions, while it is not under others. Many of the wild plants of our native meadows and pastures must now be classed as weeds, though before the land was put to use they could hardly have been so regarded. The smaller plants in a forest are not weeds, for they are of use to shade the ground, prevent washing, and protect the young tree seedlings.

677. Need for a Study of Weeds. A study of weeds is a very useful and necessary part of a study of field crops. In the production of every crop weeds must be considered. A method of treatment that is efficient in destroying one weed or class of weeds may furnish a means for the spread of some other, and it is, therefore, necessary to be able to recognize the principal weed pests and to know how to deal with them. The seeds of some of the most troublesome weeds frequently occur in grain or grass seed; hence it is important to be able to recognize them and to avoid sowing them with useful crops.

CLASSES OF WEEDS

678. Basis of Classification. Weeds are classified according to the length of time they live, as annuals, biennials, and perennials. It is desirable to know to which class any weed belongs, because the methods of combating it depend very largely on whether it lives one, two, or several years.

679. Annuals. An annual is a plant which makes all its growth in a single season. The seed germinates in the spring or summer, the plant produces blossoms and seeds the same year, and then dies. The seeds of some annuals germinate in the fall and the plants live over winter, producing their flowers and seed the following season, usually during the spring and early summer months. These plants are known as winter annuals. Corn is an example of an ordinary annual, and spring wheat is another. Winter wheat, on the other hand, is a winter annual. Ragweed, crabgrass, foxtail, and mayweed are annual weeds; shepherd's purse, corn cockle, and cheat are usually winter annuals, though the seed may not germinate till spring. Annuals spread only by means of their seed.

Figure 159.—Quack grass, or couch grass.

680. Biennials require two years to complete their growth. The seeds germinate during the spring and summer of the first year and the plants produce an extensive root system, but do not develop much top growth. The following spring they produce a large growth of top, blossom, ripen

their seed, and die. Like annuals, they spread only from seed. The bull thistle and burdock are familiar examples of biennials, as are also cabbage, turnips, beets, and a number of other garden vegetables.

681. Perennials. These are plants which may live an indefinite number of years. This class includes all our trees and shrubs, many ornamental plants, and such garden vegetables as rhubarb and asparagus. Many of our worst weeds are perennials. Some perennials spread only from their seeds; others have running rootstocks or underground stems which grow from year to year and new plants may spring up from them. Some spread by means of both seeds and running rootstocks. Perennials which spread only by seeds include the dandelion, docks, and plantains. The Canada thistle in many sections spreads only by its rootstocks and does not produce seeds; elsewhere it seeds abundantly. Other weeds which spread by both means are Johnson grass, quack grass, sow thistle, and ox-eye daisy.

THE DAMAGE DONE BY WEEDS

682. Weeds Lower Crop Yields. Weeds occupy space which is needed by crops, thus crowding them out and shading them. It is easy to see that an acre of wheat will yield less when Canada thistle or cockle or kinghead are growing in it than when the wheat occupies all the land. In the same way, Johnson grass reduces the yield of cotton, and weeds of many kinds prevent corn from making a full crop. The greatest damage is often done early in the season, by shading and stunting the crop plants before they get well started. Weeds take plant food which is needed by crops. It is next to useless to apply manure or fertilizer to land and then allow weeds to use it. Weeds also take moisture from the soil at a time when crops need it most.

Weeds lower crop yields by harboring insects and diseases. In some cases, weeds are infested with the same diseases as

are crop plants. This is true of the root rot of cotton and other plants in the South, which may maintain a foothold in fields by living on weeds when crops it does not affect are grown there. Many weeds of the mustard family help to spread clubroot of the cabbage and turnip. When the diseases do not actually live on the weeds, the latter may make conditions favorable for their development on crop plants. Thus rust and mildew are produced most readily in shady, damp situations, such as are found where the growth of weeds is rank. Weeds may harbor insects by supplying them with food when crop plants are not available, or by furnishing them a safe refuge over winter under rubbish along fence rows or in fields, thus adding to their own injuriousness.

Figure 160.—Canada thistle.

683. Weeds Lower the Value of Crop Products. The presence of weeds or weed seeds in crop products often lowers their value. Buyers of grain quite often make an unjustifiable dockage in weight or price for the presence of any noticeable quantity of weed seeds. If the grower removes the seeds before marketing, they increase the cost of production by the labor which is required to separate them from the grain. Weeds in hay materially affect the value of that product for the market or for feeding. Weeds in grain crops

make the bundles more bulky and thus more twine is required to harvest the crop. They increase the weight of the crop which must be handled, both of grain and hay. They increase the expense of gathering the crop by delaying harvesting operations, as in cotton, potato, and corn fields. Rank, succulent growth of weeds delays the curing of hay and grain crops, and may thus reduce their quality.

684. Weeds Injure Pastures. In addition to crowding out useful pasture plants and using plant food and moisture, weeds decrease the value of pastures in other ways. They may be distasteful to animals, either on account of their odor or taste or because they are armed with spines or thorns, causing stock to avoid their vicinity and thus allowing a portion of the useful pasture grasses to go to waste. They may injure animals which eat them by causing irritation, as in the case of the beards of wild barley or squirreltail grass, or they may be actually poisonous, as the loco weed of the western prairies and the laurel of the Southeastern states.

685. Weeds Injure Animal Products. Another way in which weeds injure the farmer is by causing a loss in the value of certain animal products. The seeds of such weeds as burdock, stickseed and cocklebur adhere to wool and reduce its value materially. They also injure the appearance of animals by clinging to the manes and tails of horses and the tails of cattle. Other weeds, when eaten by dairy cows, cause a disagreeable odor or taste in their products. This class of weeds includes the wild onion, ragweed, and Frenchweed.

686. Weeds Reduce the Value of Land. The presence of noxious weeds on a farm reduces its value and lessens the chances of a profitable sale. A farm infested with Canada thistles, quack grass, or Johnson grass cannot be sold as readily nor at as high a price as one which is free from these weeds. Weeds along fences and roads lessen the attractiveness of a farm.

687. Weeds May Be Injurious to Man. Some weeds are actually injurious to man. They may cause poisoning from contact with them, as poison ivy, or from eating them or their seeds. Wild parsnips are sometimes eaten for the cultivated kind, with disastrous results. The seeds of corn cockle when ground with wheat into flour are poisonous, as are the seeds of some other weeds.

Figure 161.—Ragweed.

BENEFITS FROM WEEDS

688. Uses. While most weeds are injurious, some may be of value under certain conditions. Leaves of dandelions and young shoots of pokeroot are eaten as vegetables. Many weeds furnish pasture of more or less value, though none of our domestic animals except sheep ordinarily eat weeds when the more tender and nutritious pasture plants are available. Sheep eat many kinds of weeds, and are very often useful in keeping down these pests in pastures and along fences. Weeds furnish a cover to land which is not in crop, and may prevent loss of soil fertility by leaching or by erosion. Deep-rooting weeds bring up some plant food from the lower layers of the soil, and render it available for crops which follow, They also open passages for the movement of the soil moisture and make it easier for

the roots of crops to penetrate the subsoil. Weeds add to the vegetable matter in the soil when they are plowed under and increase the plant food which is available for useful crops which follow. All these purposes are served to better advantage, however, by growing cultivated plants adapted to the particular use.

689. Weeds Make Cultivation and Rotation Necessary. Weeds are sometimes commended because they make necessary the cultivation of the soil, which might otherwise be neglected to the injury of crops. This cultivation both keeps down weeds and prevents the loss of soil moisture. Another benefit from weeds is that they often force the use of a system of crop rotation which might not otherwise be adopted. Some weeds which are practically impossible to control in grain fields soon disappear when a cultivated crop is grown or the land is seeded to grass. When mustard, wild oats, or other weeds become very plentiful in fields where small grain is grown continuously, they can best be checked by growing a crop of corn or potatoes and cultivating it thoroughly. This practice is good, even when no weeds are present, but it might not be adopted if the weeds had not compelled its use. Many weeds of meadows and pastures are easily killed by cultivation. Thus the rotation of crops is an efficient means of subduing weeds.

HOW WEEDS SPREAD

690. Dissemination. Some weeds have few or limited means of distribution, while others are provided with many agencies of dissemination. Natural agencies, such as the movement of wind and water, play a large part in the spread of weeds. Animals, both wild and domestic, carry the seeds from place to place. The activities of man, however, are perhaps the greatest factor in spreading weeds.

691. Natural Agencies. An important natural agency by which weeds spread is the movement of air currents. The

seeds of many plants are so light or they are provided with appendages of such a nature that they are easily carried long distances by the wind. The seeds of the milkweed, thistle, and dandelion spread more widely by winds than by any other means. Some plants, as the tumbleweeds and the Russian thistle, retain their seeds in the capsules for several months after they ripen. The stems are broken off by the winter winds and driven across the fields, distributing their seeds as they go. Some seeds which are not readily carried by wind alone are carried by drifting snow.

Water is an efficient agent in the spread of weeds. The seeds may float on its surface, or they may be carried along with soil or driftwood. The roots or branches of weeds may be washed out by sudden freshets or the cutting away of stream banks and be carried to new locations. Bottom lands are ordinarily infested with weeds, as the seeds are washed down from the surrounding higher lands and deposited on the bottoms.

Some plants are provided with special mechanisms which aid in their dissemination. The vetches and some members of the pea family have pods that twist suddenly when they open, throwing the seeds in different directions. Others, like the wild oats, have twisted awns or appendages which coil or uncoil with changes in the weather and aid in burying the seeds. Various other plants are provided with special means of distribution of this nature, but these are seldom efficient in spreading the plant for any distance.

Another means by which plants spread, but which tends to localize them unless assisted by water, animals, or man, is by the extension of their own growth. Quack grass, Canada thistle, Johnson grass, and many other plants increase by means of running rootstocks, which send up shoots at intervals and form new plants. Others, like crabgrass, have creeping or running stems which root at the joints and may form new plants, if broken off.

692. Animals. Wild and domestic animals both aid in carrying weeds from place to place. Some weed seeds are provided with hooks which cling to the wool or hair, as the cocklebur, burdock, and beggar's-ticks. Others are stored as food by animals or by birds and are forgotten, springing up as plants in new locations the following year. Ground squirrels, prairie dogs, and other burrowing animals store large quantities of grass and weed seeds, not all of which are consumed, and some of which are not buried so deeply that they fail to grow. Weed seeds are eaten by birds, carried by them for long distances, and then, passing through their digestive systems unharmed, are dropped in new localities. Branches of weeds bearing seeds may be used by birds or animals in building nests and thus disseminated. The droppings of live stock furnish a local means of distribution from one field of the farm to another when animals are changed from pasture to pasture or worked in the field.

693. The Activities of Man. Human operations furnish many of the methods of weed distribution, some of which are hardest to counteract. Vehicles along roads or from fields often, particularly in damp weather, carry seed in the mud which sticks to them. Tillage implements and the work of tillage furnish another means of distribution. Weed seeds or the weeds themselves may be carried from place to place on the implements, or may be moved with the movement of earth in tillage. Roots of perennial weeds are often carried by tillage tools; for this reason, poor or occasional cultivation of fields infested with quack grass, Johnson grass, or weeds that spread by similar means is often worse than no cultivation at all. Threshing machinery furnishes a ready means by which weed seeds are carried from farm to farm.

Railroads are a great agency in the spread of weeds, as they often carry weed seeds long distances in the bedding of cars, in shipments of grain, and in other material. The seeds may drop out along the right of way or be cleaned out

with the bedding at terminal points. In the latter case, they are very likely to be transported to near-by farms in manure. Many weeds first appear in new localities along the railroads, and then spread to adjoining fields.

Packing material for nursery stock and other articles which are brought to the farm from distant points furnishes another means for the spread of weeds. Weed seeds are also carried from farm to farm or from one locality to another in grain and hay which are purchased for feeding. The seeds pass into the manure and are then spread to the fields.

The sowing of weed seeds with grain, grass, or clover seeds is one of the most frequent methods by which the dissemination of these pests is effected.

METHODS OF ERADICATION

694. Weed Laws. Many states have adopted laws to prevent the spread of weeds. Weed control laws are of two forms, those which require the destruction of certain weeds along roads and railroad rights of way and, in some cases, in fields, and those which are aimed to control the dissemination of weed seeds in the seeds of grain and grasses sold by dealers. The laws in the various states differ greatly in their stringency and efficiency, some states being practically without legal means of weed control.

695. Annual Weeds. One of the most effective means of eradicating annual weeds is to prevent them from producing seeds. As they have no other means of living over from year to year, annual weeds would soon be destroyed if seed production were entirely prevented. This, of course, is not practical, but every possible means should be used to reduce the number of seeds which mature. Weeds of all kinds are killed very easily when they are small by stirring the soil sufficiently to expose their roots to the sun. Harrowing or disking will destroy weeds soon after the seeds germinate, which perhaps would survive much more severe treatment

a few weeks later. The frequent use of the cultivator helps to keep down annual and other weeds in cultivated fields. Various methods of preventing annual weeds from producing seed are suggested in the paragraphs which follow on the treatment of weeds in special crops.

696. Biennial Weeds. Biennial weeds are neither as numerous nor as difficult to eradicate as the annuals with their great powers of seed production, or the perennials with their persistent roots. Cutting off the plants below the crown during the first year or at any time in the second before the flowers are produced will kill biennial weeds. Biennial weeds are seldom troublesome in cultivated fields, for they are usually destroyed by plowing. In other locations, the quickest and easiest method is to cut off the plants below the surface of the ground with a small spade.

Figure 162.—Squirreltail.

697. Perennial Weeds. Cultivation is the most efficient means of destroying perennial weeds. Smothering the roots by preventing them from producing leaves, by frequent cultivation, by covering with straw or other material, or by sowing with some quick-growing crop like rape or sorghum, is often successful. One of the best ways of eradicating persistent perennials is to plow them under about the time the plants are coming into bloom and to cultivate the land so thoroughly during the rest of the season with the disk or spike-tooth harrow as to prevent them from producing leaves. The next season the land may be put into a cultivated crop

such as corn, cotton, or potatoes. A smother crop may occasionally be substituted for the frequent harrowings of the first year, with as good results and with far less expense, though this method is not reliable, on account of the difficulty of getting a stand sufficiently thick in every part of the field to thoroughly smother the weed growth.

Figure 163.—Bull thistle.

698. Weeds in Cultivated Fields. There is less excuse for weeds in cultivated fields than almost anywhere else. The seeds of cultivated plants are not too small to be separated readily from weed seeds, while the frequent cultivation which is given should be effective in keeping down any weeds that appear after the crop is planted. Cultivation sometimes fails to serve its purpose, because the work is not done frequently enough or at the right time, or is not thorough. The most effective cultivation may be given before the crop is planted. The land should be well plowed, and, if it is left without a crop for any length of time during the growing season, it should be disked and harrowed at intervals of a week or ten days to kill any weeds that start. Small weeds are very rapidly and effectively destroyed with a harrow or weeder. The land should be harrowed just before the crop is planted, and the harrowing may usually be repeated a few days later, either just before or just after it comes up.

With some intertilled crops, the first two or three cultivations can be given very rapidly and cheaply with the har-

row or weeder. Later cultivations should be with tools that stir the surface soil sufficiently to kill small weeds and maintain a dust mulch. Weeds that come up in the row should be hoed or pulled out if necessary, though they may often be destroyed when small by covering them with earth in cultivating. Cultivation should be continued as long as possible without injury to the growing crop, or until the ground is completely shaded. Poor cultivation, especially on fields that are infested with perennial weeds, is often worse than none at all, as it simply serves to spread the weeds. Among the most common weeds of cultivated crops are nut grass, Johnson grass, foxtail, crabgrass, quack grass, knotweed, morning-glory, velvet weed, milkweed, Canada thistle, sow thistle, ragweed, and kinghead. Weeds and poor farming go together.

Figure 164.—Wild buckwheat, or knotweed, showing the way in which it twines around crop plants with which it is growing.

699. Weeds of Grain Fields. In wheat, oat, barley, and other small-grain fields, less opportunity is afforded for the destruction of weeds than in cultivated crops. Here most of the work must be done before the seed is sown. The same kind of preparation, so far as possible, should be given as has already been recommended for land which is to be planted to cultivated crops. Great care should be taken to insure the sowing of clean seed. It is of little use to harrow

and disk land to clear it of weeds and then put on a new supply of weed seeds with the seed grain. The harrow or weeder may often be used in fields of drilled grain to destroy small weeds during the first few weeks of spring. The harrowing should be done with the drill rows rather than across them.

Figure 165. Blossom and root of wild mustard; also (1) the ripe seed pod; (2) the blossom, and (3) the seeds.

Harrowing broadcast grain will help to keep down weeds, but it will also reduce the stand of grain. Ragweed and other weeds which come up in grain fields after harvest may be prevented from seeding by mowing them when they first come into bloom, by pasturing, preferably with sheep, or by disking the land.

Among the common weeds of grain fields are wild oats, wild garlic, wild mustard, Frenchweed, peppergrass, smartweed, Russian thistle, knotweed, wild morning-glory, corn cockle, milkweed, marsh elder, ragweed, kinghead, Canada thistle, and sow thistle.

700. Spraying. The use of chemicals in destroying weeds in grain fields, and to a lesser extent in meadows, pastures, and lawns, has come into prominence in recent years. If applied while the plants are young, the chemical spray is effective in killing practically all broad-leaved plants, while it does little injury to the grains and grasses. A single

Figure. 166.—The result of spraying grain fields with iron sulphate. The portion at the left has been sprayed; the unsprayed portion at the right appears to be a solid mass of mustard.

application will kill many annual weeds and young plants of the biennials and perennials, but several applications must be made to kill the older perennials, as only the top growth will be destroyed by the earlier sprayings. The most common chemical which is used is iron sulphate, at the rate of 100 pounds to 50 gallons of water. About 50 gallons of the solution are required to spray an acre. The weeds which can be successfully treated with this spray include wild mustard, Frenchweed, peppergrass, shepherd's purse, ragweed, kinghead, and marsh elder. It is less effective on

Canada thistle, dandelion, and other more persistent weeds, unless the treatment is repeated several times. Clover and alfalfa are injured more or less by any chemical spray.

701. Weeds in Meadows. As in grain fields, prevention is more effective than after treatment in dealing with weeds in meadows. The land should be in good condition when the seed is sown, and the seed itself should be free from weed seeds. Clipping the field in the fall after the land has been seeded to grass will prevent many weeds from seeding. The seeding of weeds in older meadows may often be prevented by cutting the hay crop a little earlier than would otherwise be done. Such weeds as burdock, bull thistle, and mullein may be exterminated by cutting them off below the crown before they produce seed. Breaking up the meadow and practicing a rotation of crops may be the only effective means of eradicating some perennial weeds. The most common weeds of meadows are morning-glory, milkweed, dock, sheep sorrel, toadflax, ox-eye daisy, the plantains, orange hawkweed, Canada and other thistles, and quack grass.

702. Weeds in Pastures. In pastures, the methods of eradicating weeds are much the same as in meadows. Persistent weeds may make it necessary to break up the pasture and grow a cultivated crop. Where it is not practicable to do so, repeated mowings when in blossom or cutting biennial and perennial weeds below the surface of the ground will eventually weaken them and prevent their spread. Sheep render great assistance in keeping down weeds in pastures. Among the more common pasture weeds in different sections of the country are squirreltail grass, or wild barley, broom sedge, blue vervain, sheep sorrel, Russian thistle, milkweed, mullein, yarrow, and Canada, bull, and sow thistles.

703. Roadside Weeds. The weeds of roadsides are usually much the same as those of meadows and pastures, though on new grading annual weeds are likely to make a rank growth. Mowing two or three times during the season to

prevent the production of seed, and seeding the roadsides heavily to grass and clover will keep down weeds and prevent their spread to adjoining fields. Common roadside weeds are ragweed, kinghead, sunflowers, marsh elder, cocklebur, bull thistle, Jimson weed, velvetweed, and sweet clover.

LABORATORY AND FIELD EXERCISES

1. Let each member of the class bring in five weeds. Learn the names of these weeds and describe their most important characteristics. This study should include their habit of growth, duration and nature of root system, time of seeding, seed habits, and characters which make eradication easy or difficult.

2. Make a study of weed seeds, so that each member of the class will learn to recognize the more common weed seeds in various kinds of field seeds. Samples of grain and forage-crop seeds brought in or prepared, containing weed seeds, may be inspected and the weed seed separated and identified. Many of the experiment stations put up cases containing small samples of the more common weed seeds, which may be obtained at small cost and used for purposes of identification.

3. If small vials or cases can be provided, each pupil might make a collection of the seeds of the most common weeds of the vicinity. This exercise will be of much value in identifying weed seeds in the seeds of field crops.

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678. Eradication of Ferns from Pasture Lands in the Eastern United States.
833. Methods of Controlling or Eradicating Wild Oats in the Hard Spring Wheat Area.
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